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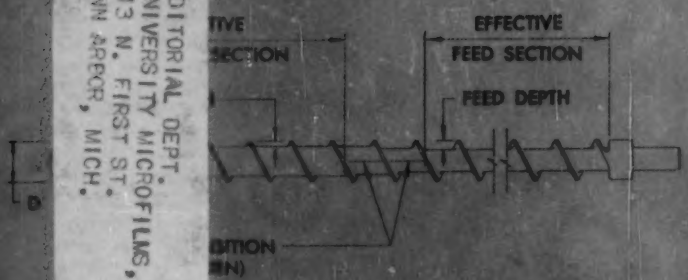

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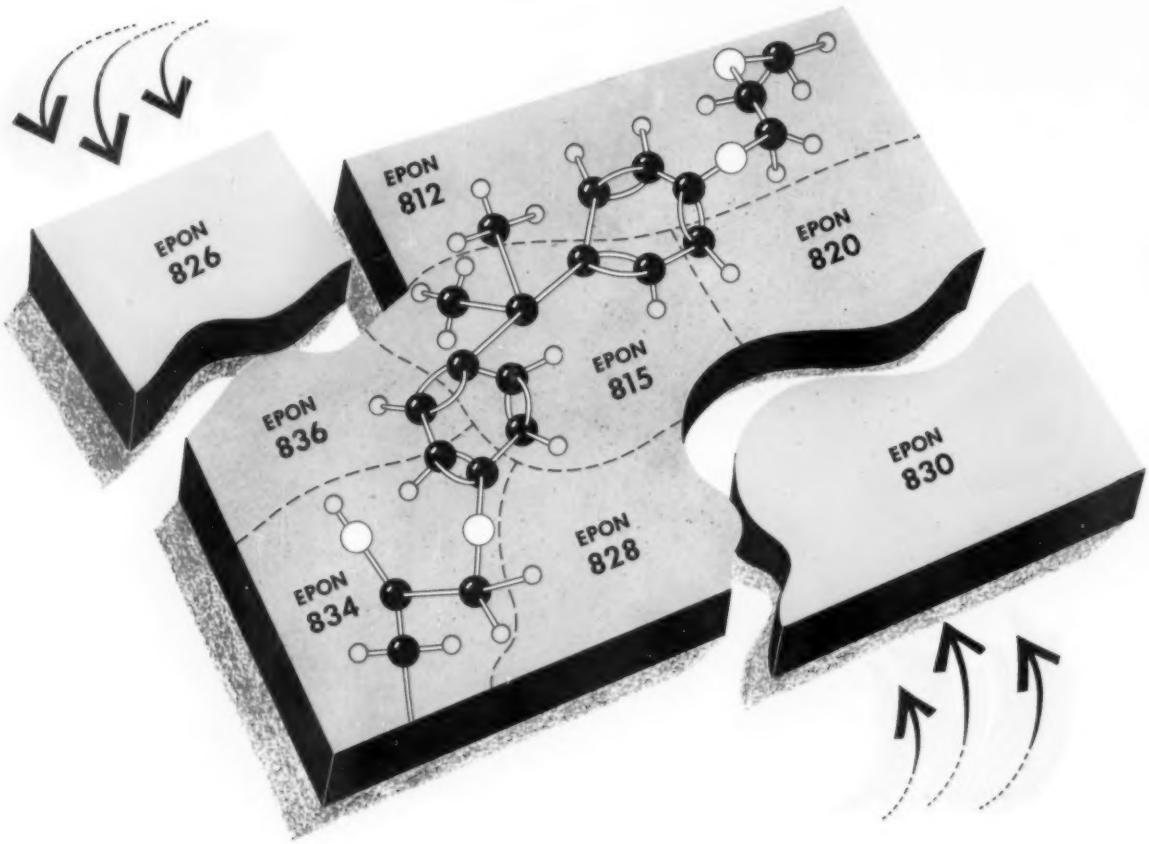

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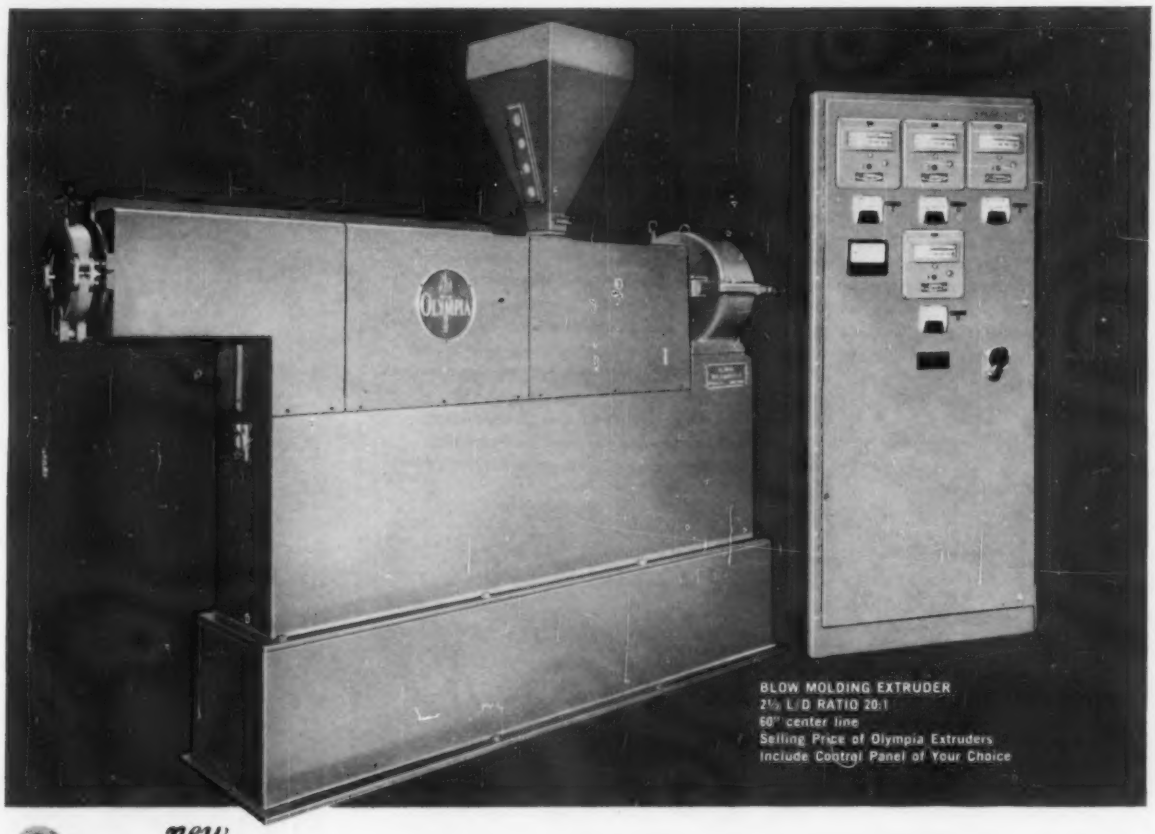
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TENITE DEVELOPMENT LABORATORY DOINGS AND FINDINGS

HAPPY HOME

Have you noticed what today's improved milk cartons are doing for the home? Modern cartons of polyethylene-coated paper allow Mother to do the shopping with less worry about milk leaking over other groceries. And Dad—well, we all know who takes out the garbage. And toting a bag not previously weakened by milk leakage does to some extent brighten his day.

With the many improvements that have been made in resins used for the extrusion-coating of paper, cartons are now more dependable than they have ever been before. With Eastman's new Tenite Polyethylene 895P-6000 Natural, for example, pinhole-free coatings have been produced at weights just above 7½ pounds per ream (about 0.5 mil). This resin—melt index 3.5 and nominal density 0.921—offers superior and uniform drawdown properties that will, in fact, permit coatings as thin as 3 pounds per ream (about 0.2 mil). Paper coaters have found it to be excellent for a wide range of coating weights.

More information is available in our Materials Bulletin 2 if you're interested.

A MATTER OF CHOICE

Both acetate and butyrate sheet are extensively used for blister, bubble, and skin packaging. Butyrate usually gets the nod when extra strength and longer shelf-life are primary requirements. Acetate—costing a bit less—meets less stringent packaging needs very satisfactorily. Eastman's technologists have developed a new formulation, Tenite Acetate 081, for the extrusion of thin-gauge sheet which makes the forming of extremely clear, deep bubbles and blisters wellnigh a cinch. In thermoformed packaging, the sheet permits deep draws without blushing.

Whichever you prefer . . . acetate or butyrate . . . you can count on high quality in these Tenite plastics. If you're uncertain which material is better for your purpose, just ask and we'll help you find out.

ALL BECAUSE OF A TEAR-TAPE

The next time you remove the top of a wrapper from a box of cough drops or a pack of cigarettes, notice how easily and smoothly the tear-tape works. Probably you've never given much thought to such an everyday convenience. Neither had we, until we began studying the possibilities of inexpensive polyethylene film as an overwrap material. Shortly thereafter, tear-tape operation became something of a hair-tearing preoccupation.

In development work with a standard high-speed cigarette overwrap machine, we found that polyethylene film could

be rapidly and smoothly overwrapped with only minor changes in the equipment. The most important machine modification arose in connection with sealing. Heated Teflon-coated rollers proved to work out nicely in producing clear, even seals.

The biggest problem, it turned out, lay not in applying the film overwrap but, rather, in opening the wrapped package by means of tear-tape. Being naturally tough, polyethylene film tore irregularly when the tape was pulled. We tried orienting the film. That helped, but not enough. To lick the problem thoroughly, our plastics laboratories took definitive action . . . they handily developed a new Tenite polyethylene formulation with the special tear characteristics needed. Tailored to a tear-tape, you might say.

For more information or for answers to any questions about the fabrication or use of Tenite plastics . . . polyethylene, polypropylene, butyrate, acetate, propionate, and polyester . . . contact either your nearest Tenite representative or Eastman Chemical Products, Inc., Plastics Division, Kingsport, Tennessee.

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An international scientific and educational organization of more than 8,000 individual members devoted to the development and dissemination of technical information in the fields of research, design, development, production and utilization of plastics materials and products. The Society is incorporated under the laws of the State of Michigan.

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plastics engineering trends of technical *significance*

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The Cover

Our cover shows a three way split this month. Education is spotlighted by the Education Committee's special report on polymer courses (page 1351); the equipment field moves ahead with a newly-developed feedscrew application index (page 1303); and applications for polyester coatings come under study (page 1317).

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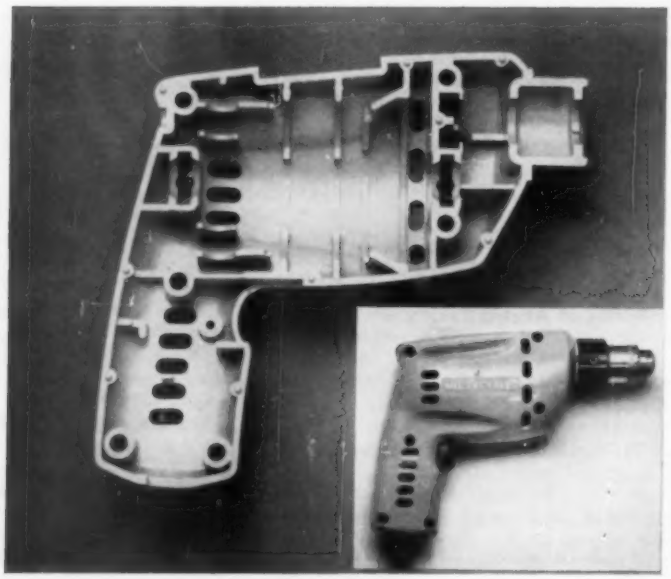
. . . through Chemistry

PLASTICS PROSPECTS

Expanding use of ZYTEL® opens new market opportunities for molders

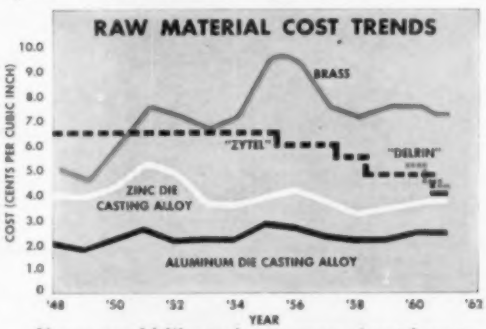


The need for improved product performance and lower costs is turning more and more manufacturers toward plastics as replacement materials for metals. Engineering plastics such as DELRIN® acetal resin and ZYTEL® nylon resins are opening vast new sales opportunities for injection molders.

The story of the new Millers Falls drill housing, at left, is a case in point. The total opportunities for the economical use of ZYTEL in the field of small power tools have hardly been tapped. In sporting goods, plumbing fixtures, mechanical applications, hardware items and many other areas, the growth of applications of ZYTEL is rapid, and offers molders opportunities for an expanded volume of business.

As prices of DELRIN and ZYTEL have continued to drop and those of aluminum, zinc, brass and other metals have continued upward, the market for parts of plastic has expanded. The chart shows these materials-cost trends.

Since parts molded of plastic require little or no finishing in comparison with costly finishing operations on metal, even when only moderate finishing is required, the completed-part cost in plastic is often lower. When the properties of the plastic fit, the business is there.



If you would like to know more about how to find business in this expanding market, please write to: E. I. du Pont de Nemours & Co. (Inc.), Dept. KK-12, Room 2507Z, Nemours Building, Wilmington 98, Delaware.
In Canada: Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

POLYCHEMICALS DEPARTMENT

New Millers Falls drill housing of ZYTEL® brings design improvements

The insulating properties of ZYTEL nylon resins make possible a drill housing that helps protect against shock hazards. In addition, this rugged and durable housing of ZYTEL is 20% lighter in weight than a comparable housing of aluminum. It is self-extinguishing. It stays comfortable to the touch in hot or cold weather, even after prolonged use. The two halves of the drill housing are molded quickly and easily by the molder. The choice of ZYTEL 31 assures good dimensional stability of the moldings, and permits a perfect match of each half for screw inserts, assembly and flange matings. No machining is necessary.

The manufacturer, Millers Falls Company, of Greenfield, Mass., reports that extensive field tests of the new drill have proved its excellent service life. The new drill also has a black collar and lock switch made of Du Pont DELRIN® acetal resin—chosen for its exceptionally good dimensional stability.

Du Pont's problem-solving engineering materials:
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	max. 0.821
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Color (Pt—Co)	max. 10
Water (Wt. Per Cent)	max. 0.10
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Initial	min. 149
Dry Point	max. 158
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EDITORIAL

Interest in Blow Molding at an All-Time High

The Regional Technical Conference (RETEC) sponsored by the Newark Section of SPE last month confirmed what a lot of people have suspected: There's great interest in blow molding. Over 700 people from all parts of the world came to hear 13 speakers cover blow molding from every standpoint—markets, applications, resins, extrusion theory and practice, and equipment.

There are still "secrets" in this fast-growing area of the plastics processing industry, and the patent situation is still clouded. But more than anything else, the emphasis now is on development of machinery engineered to a high degree of perfection. Equipment manufacturers who have been designing and building molding machines and extruders are now putting their engineering staffs to work on blow molding machines.

With efficient equipment and suitable materials, what then? New markets for plastics. We have seen how the container industry has opened markets for polyethylene and copolymers. The toy industry also was quick to see opportunities in blow molding. After that, the large volume markets will be automotive applications, then industrial applications.

Perhaps the future in automotive uses is forecast by the present in toy items. Thomas W. Mullen of Celanese Plastics Co. told the Newark audience of a 14-pound blow molded toy racing car body. Is it an unreasonable prediction that Detroit might someday be blow molding entire auto bodies? Those who have been watching developments in this industry think not. When the resin with the right combination of properties and costs becomes available, fabrication by blow molding might well be the next step.

For blow molding, a bright future beckons, but it is not a future without its problems.

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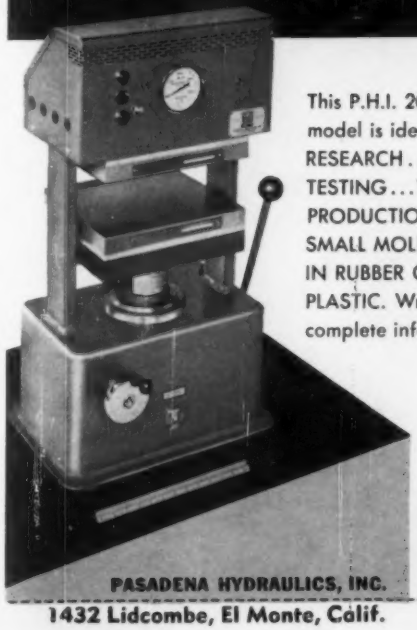
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NEW

LOW-ORIENTED STYRENE MAKES THIN-WALLED CONTAINERS UP TO 4 TIMES TOUGHER!

Even at -20°F. this BAKELITE Brand medium impact styrene can give almost four times the impact strength of conventional medium impact styrenes. The secret—low-orientation.

IN standard laboratory specimens all good medium impact styrenes check out about the same. That's how they got their name. But in an injection molded thin-walled piece? A different story. Serious loss of impact strength has been found across the "lines of flow" set up in any injection process. Remember, the piece is exactly as strong as its weakest section.

Until recently this strength loss was a fact of life we just accepted. But now, using BAKELITE Brand TMD-9020, a low oriented medium impact styrene, you can take advantage of *all* the strength originally built into the material. You get the translucency, the economy of a medium impact styrene. And you can get almost four times the molded strength of conventional materials of this type, even at temperatures as low as twenty below zero!

Containers and snap-on lids made of low-oriented TMD-9020 by Parker-Kalon. Division of G. A. T. X.

In standard laboratory "ball drop" test, regular medium-impact styrene (**left**) breaks under 4-in. drop, while new low-oriented styrene (**right**) takes ball dropped four times higher. Both samples were pre-chilled to 20° below zero F.

Think what this means to the package designer and consumer. Products can often be identified without opening the package. And these packages take to the kind of rough treatment the more fragile see-through packages could never begin to withstand. Shoppers can handle them without special care, dump them in a shopping cart, use them again at home as often as they wish.

Packaging suppliers who keep ahead will soon be offering molded plastic boxes and other containers made from this new BAKELITE Brand medium-impact styrene. Be sure you're at the head of the line. Get an idea of how low-oriented styrene will perform in *your* packaging. Remember it—BAKELITE Brand medium-impact styrene TMD-9020. It's the forerunner of other low-oriented BAKELITE Brand styrenes soon to come in other impact-resistant grades. Write today to Dept. CO-132, Union Carbide Plastics Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, New York. *In Canada:* Union Carbide Canada Limited, Toronto 12.

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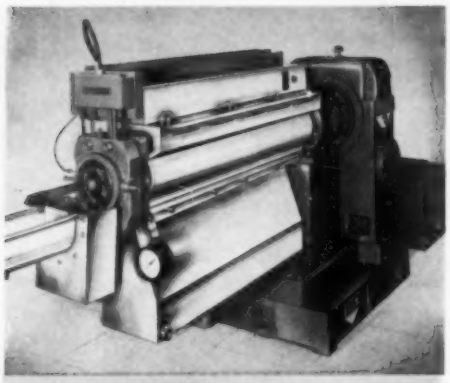

#3 (3½" bore) Royle Spirod Extruder showing section of retractable Cooling Tank.

for plastic pipe production specify ROYLE right down the line!

Royle Pipe Haul-Off units are designed for trouble-free handling of rigid and semi-rigid pipe, in a range of sizes from 2" to 6" O.D. Features include: pneumatically adjustable gripping force, cushion tensioning on traction belts, rugged steel weldment construction to match high pulling capacities and height adjustable stands. Speeds are synchronized with the Royle Extruder by a common control panel.

The new Royle Dual Coiler developed to coil flexible pipe or tubing. It features collapsible coiling heads, electric clutches for engaging heads, prewired operator's control station and constant torque drive.

If you produce plastic pipe — polyethylene, rigid or semi-rigid PVC, Kralastic, Cycolac, nylon, polypropylene or any other compound —choose Royle equipment.

Now you can get Royle quality — Royle dependability — Royle performance along your entire pipe production line — from hopper to finished plastic pipe. Every unit you need can carry the famous Royle triangle — Extruders, Cooling Tanks, Pipe Haul-Offs and Coilers; as well as all necessary auxiliary equipment, including Control Panels, Dies and Cutting equipment.

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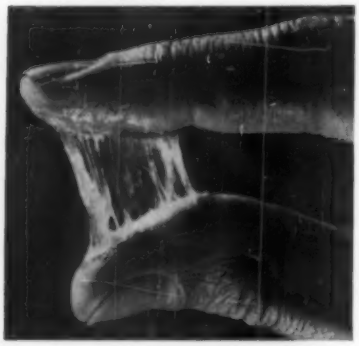
PRODUCT-DESIGN BRIEFS FROM DUREZ

- What a solvent cement can do
- Something new in electrical insulation
- A bulletin on plastics

Stuck?

A good adhesive does a lot more than stick two things together. You can use



today's solvent-type adhesives to:

- smooth out surface contours (as in brake linings and in jet aircraft skins, where adhesives can eliminate the need for projecting rivets);
- distribute stress uniformly over a surface, rather than concentrating it at welded or riveted points;
- build up large structural members from many small components;
- reduce galvanic action between dissimilar metals, and so lessen the risk of corrosion.

One super-sticker in this class sets with only contact pressure and at room temperature; adheres very well to metal, wood, phenolic laminates, glass, and rubber. Block shear tests show 4500 psi at room temperature, and tensile strength is 10,000 psi. The cement has excellent resistance to all ordinary solvents, water, oils, alkalies, and acids; has high capillary attraction and does not shrink.

We don't make adhesives. We do make heat-setting phenolic resins that give many of the newer adhesives more gripping power and more *permanence*. Next time you have a fastening problem, give these new solvent-type adhesives a chance to show you what they can do.

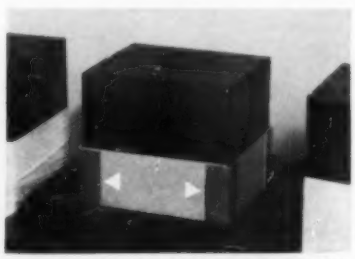
Stock insulation shapes

This insulation idea solves three engineering problems at once in a dry-type transformer. You'd find the same approach helpful in a circuit breaker, a panel, or other heavy-duty electrical gear.

See the plastic angle pieces (below)? They insulate the corners of the laminated steel core from the windings, at the high-stress areas. They take the place of roll-formed fiber. Advantages:

1. Greater mechanical strength. This ends cracking or breaking of insulation when windings are forced into position.
2. Better resistance to moisture. The insulation doesn't swell or shrink, maintains its dielectric strength under the clammiest conditions.
3. Higher heat resistance. The angle is made with glass-reinforced Hetron,® our inherently heat-resistant polyester resin. It meets NEMA GPO-1 specifications, and has UL-recognized flame retardance. It is designed for equipment operating at Class B temperatures (266°F.).

Now for the clincher. You can get flame-retardant structural insulation like this *from stock*—in a wide range of cross-section shapes including channels, in widths up to $9\frac{21}{32}$ inches, lengths to 76 inches.



PRECISION WELDER AND FLEXOPRESS CORP.

You get them not from us but from the manufacturer, The Glastic Corporation, 4321 Glenridge Road, Cleveland 21, Ohio. The Glastic people will be glad to send you details on stock channels and angles if you write to them.

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What does a man do when he wants to know more about Durez plastics?

He looks in Sweet's File. There he finds eight pages packed with the what, how, when, where, and why of using Durez materials—phenolic and diallyl phthalate molding compounds, Hetron polyester resins, phenolic resins.

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For more information on Durez materials mentioned above, check here:

- ☐ Phenolic resins (12-page bulletin listing applications)
- ☐ Hetron fire-retardant polyester resins (data file, including names of fabricators)
- ☐ Durez plastics (*Bulletin D400*)

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DUREZ PLASTICS DIVISION

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HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

SPE JOURNAL NEWSLETTER

reading time
1 minute

Plastics on Papermaking Machines

Crosslinking of technology in the fields of paper, textiles, and plastics could lead to the possibility of making a hybrid paper-plastic combination—not a laminate—on papermaking machines at speeds up to 2400 feet per minute. This compares with present film extrusion rates of about 150 feet per minute. At least one company is now working on the idea.

Polyester Coatings

Polyester coatings for masonry and metal surfaces, showing excellent weatherability and chemical resistance, are moving toward wider application. (Page 1317) These coatings are now in commercial use on masonry, especially in the Detroit area, and as a clear spray coating for protecting automotive trim and other metal surfaces. A multi-million dollar application is possible: European auto builders are testing an experimental body finish.

Montecatini Sues Japanese Firm

Montecatini has filed a lawsuit for infringement of its polypropylene patents against Shin Nippon Chisso, a polypropylene importer and producer. Chisso has requested Japanese government approval for a joint polypropylene production venture with AviSun. Montecatini claims this operation would lead to conflicts with basic and improvement patents filed in Japan by Herman Ziegler and by Montecatini.

Cementable FEP Film

A new bondable form of FEP (fluoroethylene-propylene polymer) film may be potted, printed and cemented with many standard adhesives, including epoxy resins and rubber adhesives. Possible applications include chemical and cryogenic tank linings, release coatings on heated and chilled rolls, hose liners and jackets for chemically resistant diaphragms and seals.

Plastics for Architects

Plastics in buildings gain ground. Some examples: Stressed skin modular panels with foamed polystyrene cores are being used for wall construction; PVC and PVC-polyvinyl acetate copolymer coatings are being used as weather-resistant coatings, good for 15 years on aluminum siding. And a final note—The Japanese are said to be ready to introduce in this country an all-PVC house, with a price tag of about $2000.

new technical ideas • trends • industry news

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CYMEL 3135 – 3136 (glass-filled) Additional distinctive properties: outstanding electrical properties; high impact resistance; extraordinary flame resistance; good dimensional stability. Typical applications: circuit breaker boxes; terminal strips; connectors; coil forms; stand-off insulators. Specifications: Cymel 3135 (MMI-30, MIL-M-14E, Federal L-M-181 Type 8; ASTM D704-55T Type 8); Cymel 3136 (MIL-M-19061, MMI-5).

CYMEL 592 (asbestos-filled) Additional distinctive properties: resistance to atmospheric extremes; high dielectric strength. Typical applications: connector plugs; terminal blocks; a/c, automotive and heavy duty industrial ignition parts. Specifications: MIL-M-14E MME; Federal L-M-181 Type 2; ASTM D704-55T Type 2, SPI SPEC NO. 27025.

CYMEL 1077 (alpha cellulose-filled) Additional distinctive properties: Surface hardness, heat resistance, unlimited color range. Typical applications: appliance housings, shaver housings, business machine keys. Specifications: MIL-M-14E – Type CMG (in approved colors); Federal L-M-181 Type 1; ASTM D704-55T Type 1, SPI SPEC NO. 30026.

CYMEL 1500 (wood flour-filled) – CYMEL 1502 (alpha cellulose-filled) Additional distinctive properties: Good insert retention. Typical applications: meter blocks, ignition parts, terminal strips. Specifications: Cymel 1500 (MIL-M-14E Type CMG, Federal L-M-181 Type 6, ASTM D704-55T Type 6); Cymel 1502 (MIL-M-14E Type CMG, Federal L-M-181 Type 7; ASTM D704-55T Type 7.

BEETLE® UREA (alpha-filled) Additional distinctive properties: Economy of fabrication, economy of material, myriad translucent and opaque colors. Typical applications: wiring devices, home circuit breakers, tube bases, appliance housings. Specifications: Federal L-P-406A, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM), SPI SPEC NO. 27026.

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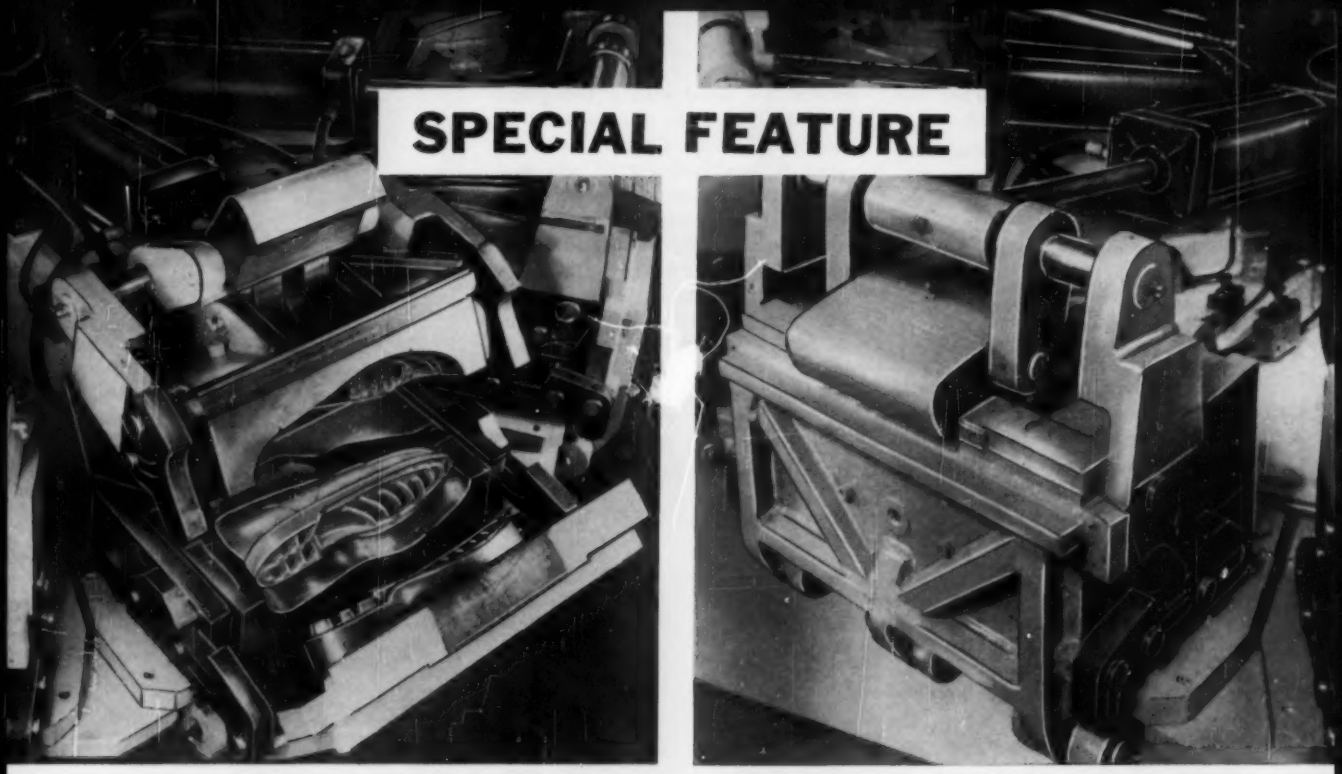


Heavy-duty sports shoe being molded in Foster-Wucher air operated shoe mold.
Photograph at left shows mold and carrier in open position.
Photograph at right shows shoe mold carrier in closed position.

Injection Molding Applications for the Footwear Industry

International Vulcanizing Corp.
Gordon Cooper

Growth of the plastics industry traditionally has been limited only by the imagination. And the imagination is the only limiting factor for the possibilities for plastics in the footwear industry. This article describes some of the specialized equipment now available and some of the products currently being manufactured

The machines for manufacturing footwear are, basically, extrusion and injection molding machines (SPE Journal, Nov., 1959, page 966) which utilize a specially-designed revolving screw to convey the compound through the heating cylinder and to supply the injection force on the plasticized material in conjunction with an air-operated rotary table containing ten air-operated mold carriers. The molds are automatically presented successively to the injection head. In operation the molding compound, whether it is pellets or dry blend, is fed from the hopper by gravity to the variable feed vibrator located directly above the barrel.

The mold carriers, each containing a single or multi cavity mold, automatically positions so as to line up with the nozzle of the barrel. Mechanical pressure is then automatically applied, depressing the valve in the nozzle and allowing the material to flow into the cavity which coincides with the automatic starting of the following:

1. The variable speed compound vibrator.
2. The rotation of the screw.
3. Pressure build up.
4. Automatic devices which shut

off the entire cycle when the cavity or cavities are full.

5. Automatic indexing of the rotary table to position the next station for loading as well as the automatic opening of the mold box for unloading of the finished product.

All Plastics Sandals

In molding plastic sandals, each mold carrier contains a one foot mold which is comprised of two half cavities which represent the upper portion of the sandal, the last and the sole plate. All sections, except the last, are bolted to the mold carriers by two bolts for each section which are located so as to be easily accessible for mold changeover.

In operation the operator places the last in the mold after which the mold carriers close on the complete mold. It is then presented to the injection nozzle for filling. After filling, the turntable turns automatically and positions the next mold carrier to the nozzle for filling. At a predetermined station, the mold box automatically opens and the operator reaches in and removes the last from the mold cavity and strips off the finished sandal and returns the last to the cavity. In volume production there is usually a second last so that the actual stripping of the shoe is done by the person who inspects the sandal and assists in packing.

Of particular interest is the small injection sprue which is not attached to the all-plastics sandal. Due to the special tapered design of the orifice in the mold carrier, the sprue is easily removed.

The Foster Wucher® FW700 is capable of molding 176 to 220 pounds of material per hour, depending upon the type of compound. Present production figures are 1000 pairs of various sizes of strap sandals in eight hours.

Unit Molded Outersoles

Of particular interest to the footwear industry is the application of this injection molding machine for the unit molding of individual outersoles complete with heels in various irons of thickness with PVC compounds and dry blends.

This automatic molding operation is identical in all respects to all plastics sandals excepting that the mold carriers are fitted with a two piece low-cost alloy mold manufactured to the customer's specifications, with respect to the thickness of sole and heel, outersole patterns, and sole bottom design. These molds are also equipped with devices that automatically fill and shut off the injection cycle so as to obtain a finished outersole and heel without any flash or sprue. The small injection point is located on the inside shank portion of the sole and is not visible on the wearing surface. The inside portion of the heel is of honeycomb design so as to provide lightweight, durable outersoles.

An important feature of this type of outersole, with respect to shoe manufacturing, is that it is ideally suited for certain welt construction whereby the welting material on the shoes is made of similar vinyl compound as the outersole. The outersole is permanently fused to the welting by the application of heat and pressure which is applied between the welting and the outersole. Then again, it is quite possible to McKay or Littleway stitch a lightweight PVC midsole and then attach the outersole with suitable adhesives and existing equipment. Outersoles of this type are now being used by many shoe manufacturers.

Heel Molding

Of special interest to the manufacturers of women's high and flat heels is a 4-nozzle head or manifold which is attached to the end of the barrel of the FW 700. The 4-nozzle head or manifold is equipped with a pressure sensing device and time delay which permits optimum injection conditions to be obtained and reduces to a minimum the formulation of flash and sink marks when molding thick section items.

The 4-nozzle head provides a heated runner and enables injection of material to be made directly into the center of each of the 4 cavities simultaneously, thereby dispensing with the need of gating the mold. The 4 cavity mold carriers are also fitted with a sprue ejection device which is operated at the unloading station. Ejection of the four sprues from the orifice in the mold carrier occurs before the mold carrier is opened, thus protecting the product from deformation. When opened, the mold carrier presents four complete individual moldings without sprues or gates. Due to the ideal accessibility of the mold cavities, it is quite practical to place inserts in them before injection.

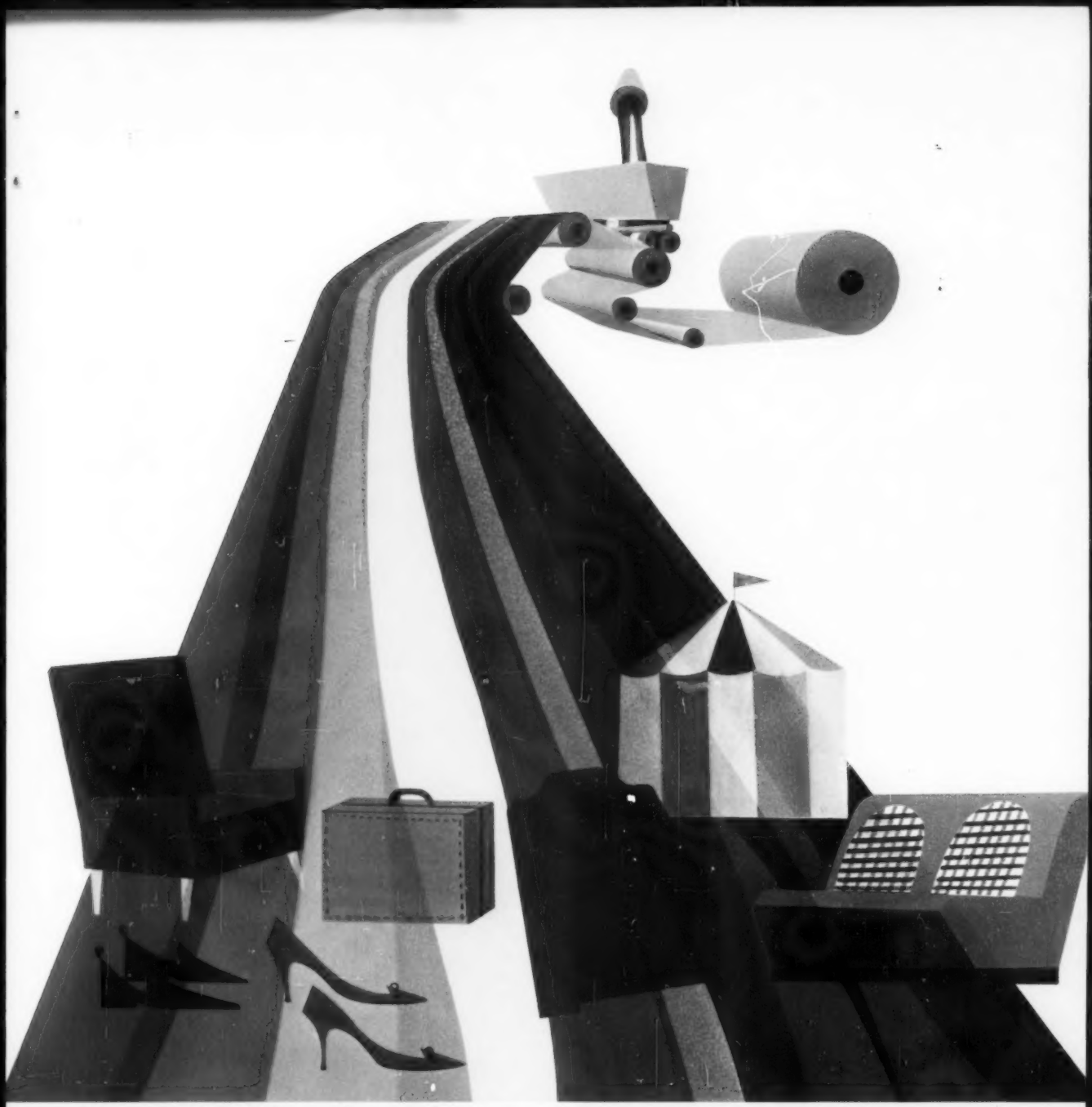
The Foster-Wucher Hand Operated Heel Mould Carrier in Open position showing 4 single cavity Heel Moulds

Low Cost Molds

Still another important feature is that low cost alloy molds are now being used in the volume production of various items and, as an illustration, the price per mold for all plastics sandals is currently $600.00 to $1,000.00 each. The unit molded outersoles and heel molds are currently priced at $250.00 each and a four cavity women's high heel mold is currently priced at $1,000.00.

Direct Sole Molding

Of particular interest to the footwear industry is the application of certain features of this machine for the direct injection molding of suitable compounds to leather footwear. Because of the close relationship of direct sole molding of both rubber and vinyl compounds, it is quite obvious that similar types of molds can be used for both methods.



Diamond PVC 70 Resin "behaves" as it coats paper and fabric for durability and glamour

Even the most inexpensive products take on a deluxe look and "feel" when Diamond PVC 70 is used. Experienced coating personnel are finding it ideal to use. Here's why.

This new vinyl dispersion resin for plastisols and organosols imparts exceptional flow properties and viscosity stability which make application faster and easier. It permits wider compounding latitudes and allows formulation for a broader range of toughness and "hand". Ideal for knife as well as reverse roll coating systems.

Other industries are also finding PVC 70 has more to offer. For example: fewer viscosity adjustments in recycled plastisols for dipping and molding; also, sprayable compounds go on smoothly and rapidly.

Diamond PVC 70 is one of the most thoroughly pretested dispersion resins ever marketed. Over a million pounds were produced to insure uniformity pound after pound. Try it in your plant.

Other new vinyl dispersion resins are now in final testing stages by Diamond. Look for them. Experienced sales and technical service personnel at your service. Diamond Alkali Company, 300 Union Commerce Bldg., Cleveland 14, Ohio.

Manufacturers of a complete line of calcium carbonates such as Surfex MM®, Kalite®, Multifex MM®, Chlorowax® secondary plasticizers; and Diamond PVC resins for the plastics industry.

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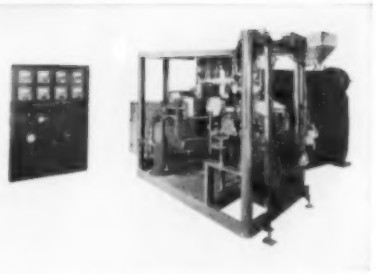
You see your MPM Extruder in action... before you buy it

MPM doesn't sell merely extruders — it sells *production*. When you order an MPM extruder, you know exactly what caliber of performance you can expect, because you've seen it perform . . . had a chance to test every part before purchase.

Moreover, many extruders today are "patch-quilt" affairs: one piece made by this company, a second part by that, a third by still another. Not with MPM. For MPM manufactures virtually all its own components: grinds its own screws, assembles its own controls . . . all precision-built to MPM standards in MPM's, modern 90,000 sq. ft. plant.

Screw diameters available range from 1 to 12", in vented or non-vented design, and in L/D ratios of 20:1, 24:1 or longer. Either resistance-band heaters, cast-in heaters or induction heating can be specified. Extra heavy-duty thrust bearings, Xaloy-lined barrels, and precision-ground screws are typical of rugged MPM components. In short, MPM extruders are tailored for your specific needs, then proved out to you before you buy. More information? Just write Modern Plastic Machinery Corporation, 64 Lakeview Avenue, Clifton, N. J.



INTERESTED IN BLOW MOLDING? Then you'll be interested in the new MPM "Diversamatic." Molds from polyethylene, polypropylene, high-impact styrene, acetate, nylon, other materials. Handles molds up to 36" long, 21" wide, 28" daylight. 14" stroke. Automatic built-in electric counters. All-pneumatic system. Works with any extruder, either U.S. – or foreign-built.

mpm **Modern Plastic Machinery Corporation**

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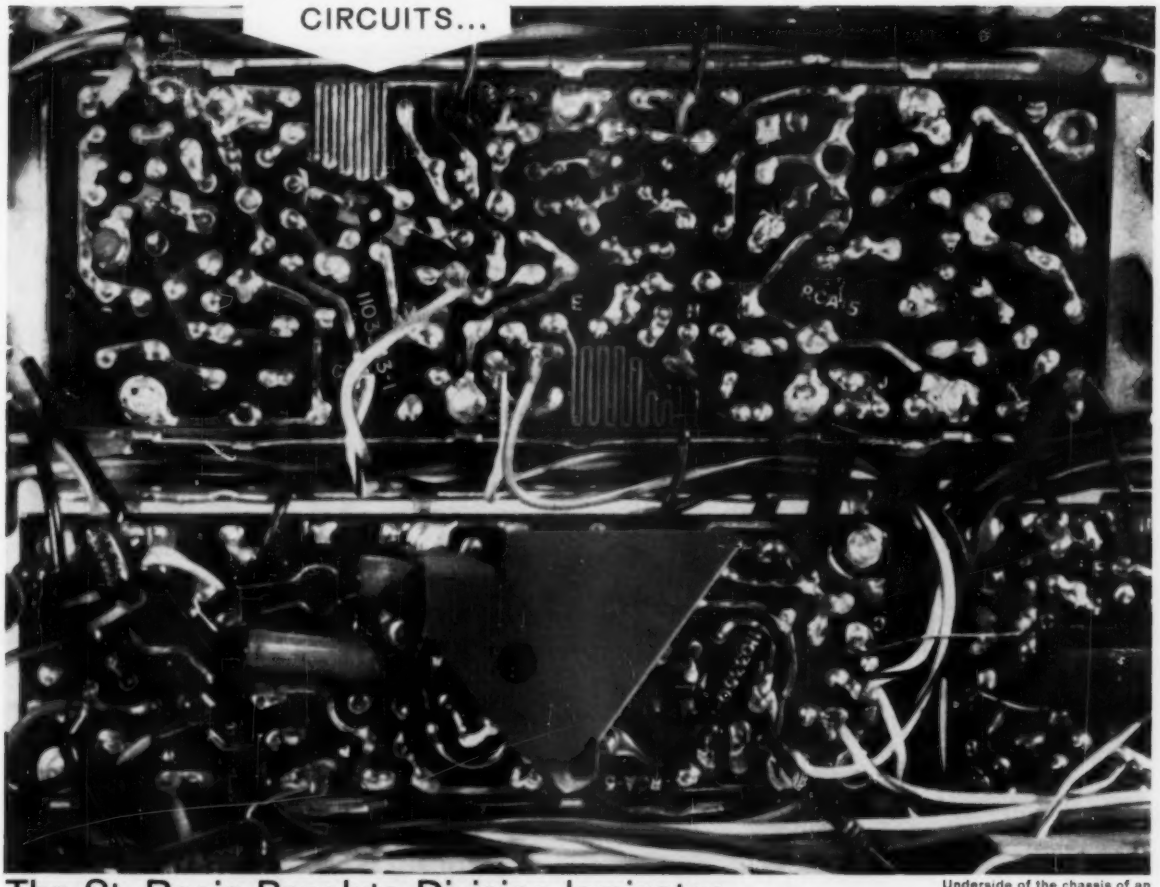

Underside of the chassis of an RCA color television receiver showing extensive use of printed circuitry on St. Regis stock.

The St. Regis Panelyte Division laminates cold punching stock with

RCI PLYOPHEN 5888

Phenolic Resin

RCI PLYOPHEN 5888 has proved exceptionally suited for laminating printed circuit stock to meet NEMA XXXPC requirements and the corresponding government grades.

St. Regis-Panelyte, for example, makes extensive use of PLYOPHEN 5888 in its XXXPC Grade 810 laminate. Mr. George E. Vybiral, chief engineer, credits this Reichhold phenolic for achieving "optimum uniformity... required for automated assembly operations . . . in printed circuitry."

St. Regis-Panelyte and other users report that PLYOPHEN 5888 excels in all of these important characteristics: 1. good cold punching properties 2. exceptional insulation resistance 3. low water absorption 4. high impact strength 5. resistance to corrosion 6. ease of machining 7. excellent performance under high soldering temperatures.

Reichhold's PLYOPHEN line also includes phenolics developed specifically for producing general purpose laminates, rolled tubing, alkali-resistant laminates and hot punching stock . . . as well as varnishes for a variety of other applications.

If you manufacture industrial laminates, RCI has the resin you need.

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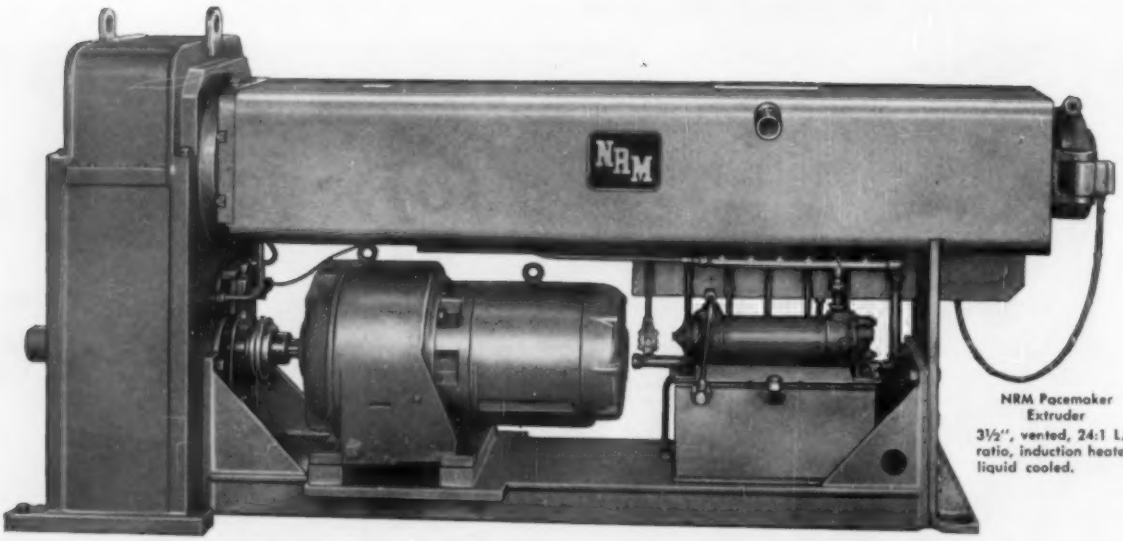

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3½", vented, 24:1 L/D ratio, induction heated, liquid cooled.

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you can increase production up to 3½ times, without increasing extruder floor space!

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And, NRM's Pacemaker offers modular building block construction . . . drive gear and thrust bearing components can be tailored *exactly* to your production requirements. Too, you can choose new Temp-Flo liquid or balanced air cooling and induction or resistance heating, to assure close control and highest product quality. Pacemakers are offered in 3½", 4½" and 6" sizes, 20:1 and 24:1 L/D ratio, vented or unvented. Call, wire or write NRM today for application engineering recommendations.

- *For more information, write for free Bulletin PM-100. Address National Rubber Machinery Company, 47 W. Exchange St., Akron 8, Ohio, Dept. MP-560.*

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SPEAKING OF EXTRUSION

Feedscrew Application Index For Long Metering Types

Better product uniformity and higher extrusion rates possible by using newly-developed feedscrew selection chart

Although considerable effort has been expended in recent years in the area of feedscrew analysis, there seems to have been a reluctance on the part of both user and manufacturer to depart from the "tried and true" profiles.

It also seems difficult to avoid identifying feedscrews by associating specific designs with the plastic resins involved. However, now that an improved form of the metering screw has appeared on the scene, consideration may be given to the establishment of a new series of profiles which incorporates the general rules uniformly covering a broad range of application.

The Application Index, or Feedscrew Selection Chart, refers to a series of feedscrew profiles for 2½ inch, 20 to 1 (L/D) extruders. The basic series extends from a feedscrew having a 9 turn metering section and a .105 inch channel depth to one with 5 turns and a .185 inch channel depth. All feedscrews in this series are based on the long metering principle which was recently introduced by Bruce Maddock of Union Carbide Plastics Company. (*1*) Employing the fundamental recommendations of this publication, a number of feedscrews

Feedscrew Selection Chart (2½" 20 to 1 L/D Extruders)

Resin	Application (Product)	Feed	Operating Classifications (see Table 2)				Screw Profiles (Table 2)
			RPM	Extrusion Viscosity	Normal Die Pressure	Total Power Req'd	
POLYETHYLENE	PAPER COATING	PELLET	HI	LO	LO	MED	9E, 9F, 9G
POLYETHYLENE	FILM	PELLET	MED	MED	MED	MED	9F, 9G, 8H
POLYETHYLENE	RIGID TUBING	PELLET	MED	HI	MED	MED	9F, 9G, 8H
POLYETHYLENE	REPROCESSING	CHIPS	HI	MED	MED	MED	9F, 9G, 8HR
POLYETHYLENE	REPROCESSING	FILM	HI	MED	LO	MED	9F, 9G, 6HR
LINEAR POLY.	RIGID TUBING	PELLETS	MED	HI	HI	MED	9F, 9G, 8H
LINEAR POLY.	RIGID SHEET	PELLETS	HI	MED	MED	HI	9F, 9G, 8H
POLYPRO	GENERAL	PELLETS	MED	HI	HI	HI	7FR, 9F
NYLON	GENERAL	PELLETS	HI	LO	LO	MED	9E, 9F, 9G
NYLON 6	GENERAL	PELLETS	MED	MED	MED	HI	9F, 9G
GP POLYSTYRENE	PROCESSING	BEADS	HI	MED	MED	MED	9F, 9G, 7GR
HI POLYSTYRENE	RIGID SHEET	PELLETS	MED	MED	MED	MED	9F, 9G
HI POLYSTYRENE	REPROCESSING	CHIPS	HI	MED	MED	HI	9F, 9G, 8H
ELASTIC VINYL	GENERAL	PELLETS	MED	MED	MED	MED	8H, 7J, 6K, 5L
RIGID VINYL	GENERAL	PELLETS	LO	HI	HI	HI	6k, 5L
ELASTIC VINYL	GENERAL	DRY BLEND	HI	MED	LO	MED	9G, 8H, 7J, 6HR
ACRYLIC	SHEET	PELLETS	MED	LO	LO	MED	8H, 7J

Table 1. Screw Profiles—Long Metering 2½" 20 to 1 L/D Extruder

Type	Meter Depth	Meter Length (turns)	Trans'n (turns)	Feed Depth
9E	.105	9	1	½
9F	.115	9	1	½
9G	.125	9	1	½
8H	.135	8	1	½
7J	.150	7	4	½
6K	.165	6	5	½
5L	.185	5	6	½
7FR	.115	7	1	½
7GR	.125	7	1	½
6HR	.135	6	1	½

NOTES: "R" Added to Type means Homogenizing or Restricting Ring added. Width of Ring is ¼ Dia. (⅝ inch), Radial Clearance is .030 Inch.
"Turns" refers to Revolutions of Channel.

Table 2. Operating Classifications**

Class	RPM*	Extrusion Viscosity (Examples)	Normal Die Pressure	Power Req'd* (HP)
LO	25-50	Paper Coating (Hi-Temp.)	500-1000	10-15
MED	50-100	Strands, Pelletizing (Med. Temp.)	1000-2000	15-25
HI	100-200	Rigid Tubing (Lo Temp.)	2000-4000	25-40

* For 2½" Extruder
** NOTE: No Single Classification (LO-MED-HI) Applies Uniformly For All 4 Operating Conditions

was made and evaluated in laboratory and production installations. The most important advantages observed were a pronounced improvement in product uniformity and a consequent increase in extrusion rate.

Higher production is achieved through increased screw RPM which is made possible by the inherently improved quality. It will be noted that for polyethylene, the metering section is about twice as long as that normally used, but the channel depth is about 20% greater. The typical profile is illustrated in *Figure 1*.

It does not appear to be feasible in a tabulation such as presented here to pin-point one specific profile for each general application. Variations in compounds, extrusion viscosities, pressures, temperatures, and in quality or production rate requirements rather indicate that a group of three closely related profiles be offered. This will not only give the purchaser a better opportunity to influence the selection of his feedscrew, but will also simplify the effort of determining which type of feedscrew might best serve for a number of applications involving different plastic compounds.

The dimensions of the feedscrews in the suggested series are shown in *Table 1*. An extension of the basic series (types 7FR, 7GR, and 6HR) makes use of a smooth restrictor ring located at the entrance to the metering section. The purpose of this element is to provide an added degree of homogenizing for operations in which intensive mixing is desired.

To establish the proportions for larger or smaller diameter feedscrews, the following relationship between metering section channel depth (h) and screw diameter (D) should be used:

$$\frac{h_1}{h_2} = \sqrt{\frac{D_1}{D_2}}$$

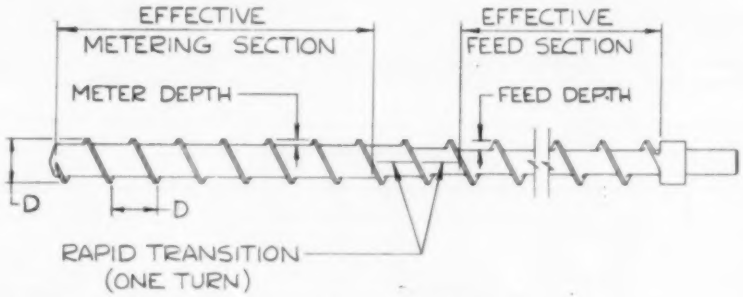

Figure 1. Typical feedscrew with one turn transition

The Operating Classifications are identified in *Table 2*. These are intended to serve as a general guide and help to clarify the applications. Not all the specific profiles listed are based on actual performance data. It is felt, however, that a comparison of the results obtained with long metering and conventional screws serves as a reasonable basis for extending the principle into other areas.

Sample Results Obtained With Long Metering Feedscrews

1. Polyethylene (approx. 3.0 Melt Index); 3000 PSI; 155 RPM; 190 LB/HR; 370°F Melt Temp; 8 LB/HR/HP; Product: strands; Quality Good; Screw Profile 9F (2½" extruder)[2]
2. Linear Polyethylene; 2500 PSI; 70 RPM; 120 LB/HR; 350°F Melt Temp; 10 LB/HR/HP (approx): Application: Blow Molding; Quality: Good; Screw Profile 8H (2½" extruder)
3. Hi Impact Polystyrene: 90 RPM, 800 LB/HR. Application: Sheet; Quality: Good: Screw Profile 9F (4½" extruder)
4. Polyethylene (Approx. 3.0 Melt Index) 3000 PSI; 200 RPM; 220 LB/HR; 420°F Melt Temp; Product strands; Quality Good. Screw Profile 9F (2½" extruder)[2]

Literature References

1. Maddock, B. H., "Pressure Development in Extruder Screws", S.P.E. Journal, April, 1960
2. Waechter, C. (Hartig Laboratory Report, 3/24/60)

Edited by **Bruce H. Maddock**, *Union Carbide Plastics Co.*

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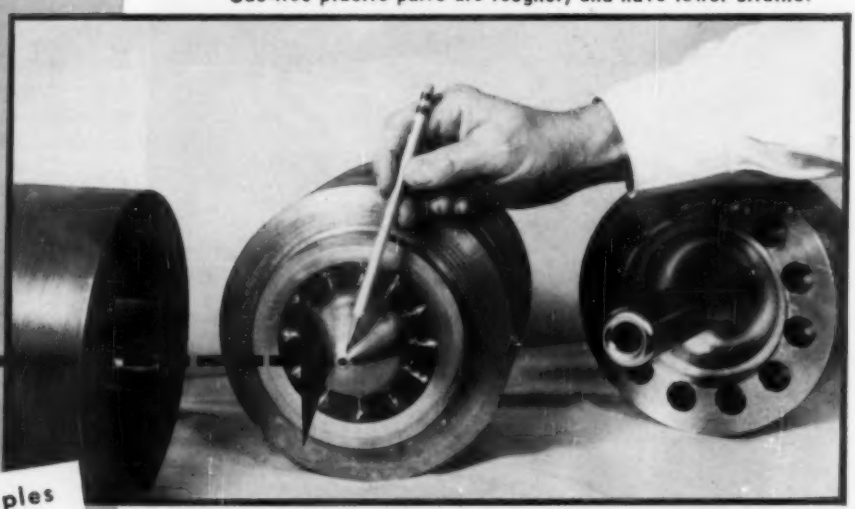

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MOLDING CYCLES

Automatic Compression Molding

Replacement of semi-automatic presses with automatic presses is attractive to Canadian molders whose relatively small volume of production favors 8-hour daily operation.

There are six factors that determine production costs of a plastic part. These are: Part design, volume, mold, equipment, cycle time, and efficiency of the operation. This article takes a look at each of these factors and details their effect on relative costs of compression molding on automatic and semi-automatic equipment.

Part Design

This is the most important factor in the cost of the part. The skill of the designer fixes the material and equipment to be used, the cavity cost and cycle time, and to some degree the efficiency of the molding operation. For instance, the material used for the part depends on its function, impact resistance, dielectric strength, appearance, shrinkage factor, and structural strength.

The shape and cross-section of the part is determined by its function. These in turn affect cycle time and dictate the molding method, whether it is compression or transfer molded.

Coring plays an important role in part design. This is used primarily to reduce the material cost and cure time. However, long, thin cores mean mold pin breakage, or more expensive mold cost, or the higher equipment and operating cost of transfer molding. A length to diameter ratio of core pins should be no more than 2.5:1 for automatic compression molding.

Insert molding lends itself to a semi-automatic operation. If the volume is high, an automatic insert loader reduces the labour cost, but increases the equipment cost. Inserts can be fastened automatically in a separate operation after molding.

Side-cores and threads also mean higher equipment cost. However, they can be run automatically, even on small presses. Side-cores can be molded into the part without using side-draw attachments. This is done by overlapping opposing pins in force and cavity to make the shape of the hole.

Volume

This element is not as important for automatic molding as it is for semi-automatic operation. A single cavity can turn as many as 10,000 parts in one week with minimum tool cost and almost negligible labor cost. The original, short-run of the part should be set up on automatic operation to provide minimum press and tool investment for the best machine utilization. Two or more parts every six months may be needed to provide enough molding time.

As the volume of the part increases, additional units of mold and press may be added. The extra capital investment is justified in the same way the original short-run was justified. With four complete units molding, a breakdown in one unit means only a 25% loss in production.

The floor space required for two complete units is less than that of a larger press running semi-automatically, and the investment and operating costs are greatly reduced. See the comparison of molding costs, which follows, to illustrate this point.

The flexibility of multiple units allows the molder to break into molding runs without completely disrupting production.

Mold

This cost is very dependent on part design, which determines the detail, finish, configuration and equipment used.

A common fallacy of many molders is to attempt to save a few hundred or even a thousand dollars on their mold by taking the lowest tool quotation. There are many qualities built into a mold that are not evident to the untrained eye. Qualities such as finish and accuracy reduce the set-up time, the run-in time, and provide the high efficiency that a fully automatic molding operation needs. The best automatic press in the world will not produce quality parts efficiently from a cheap mold.

Equipment

Automatic molding equipment has developed to the point that reappraisal of many existing plastics parts is needed. New applications of old automatic press principles have led to fully automatic transfer molding presses of 50 tons to 200 tons capacity.

A small press, specifically designed for short-run automatic transfer molding of small parts, has a 25-ton clamp and 5½-ton transfer ram, using cold powder. It is also used for automatic compression or semi-automatic insert-molded parts.

Another new press of 150-ton capacity is designed for insert-molded parts.

Cycle Time

This variable depends mostly on cure time, which is about 90% of the molding cycle. The part designer tries to minimize this.

Control features such as low-pressure close, mold breathe, double-shot and flash thickness control switches, have added seconds onto the dry cycle of automatic presses. To compensate for this, press manufacturers added adjustable daylight and the regenerative circuit (fast approach) to reduce the dry cycle time once more.

The greatest reduction in cycle time came with the integral preheater for powder, which mounts right onto the standard feeding board. Material is agitated for exposure under a variable heat source, prior to its entry into the feed tubes. Cure reductions as high as 30% have been experienced. Material suppliers brought out fast-setting resins to further reduce cycle time.

Efficiency

The automatic molding operation's efficiency depends on the press, the mold, and the material.

The press must be capable of cycling by itself, unattended, 24 hours a day, with raw material being supplied to the hopper, and ejected parts collected. The ejection mechanism should be positive to maintain control over the molded parts to prevent them from accidentally falling back into the mold, and to remove all traces of flash after each cycle.

The mold should be polished to produce good finishes and prevent flash from sticking to the mold faces. The mold design should reflect the minimum of complications of the part design. The quality of steels used and the methods of machining molds should be discussed at length by someone well qualified.

Many new materials have recently been developed to run in automatic presses. Bulk factors and plasticity grades are more uniformly held. This uniformity allows closer tolerances and better quality parts.

Automatic vs. Semiautomatic Molding

Comparison of molding costs between various sizes of automatic compression presses and a 200-ton straight-ram, semi-automatic compression press molding the same part reveals some interesting facts (above).

The 200-ton semi-automatic press has one operator who removes the molded parts from the press, transfers the heated preforms to the cavities, closes the press, and starts the press cycling. The automatic presses are all equipped with an integral powder pre-heater, and we shall assume that the combs and feeding mechanism take as long as it does the operator to perform his motions. Therefore, it can be assumed a simple part has a molding cycle of one minute on any of the presses.

Comparison of Several Sizes of Automatic Presses with A Semiautomatic Press

Part Compared: 4¼" x 3¼" GP phenolic electrical wall-plate

	150-Ton Automatic	75-Ton Automatic	50-Ton Automatic	25-Ton Automatic	200-Ton Semi-Automatic
Floor Space Sq. Ft.	80	75	75	30	70
Efficiency %	95	95	95	95	80
No. of Cavities	6	3	2	1	8
Production/Week					
7 24-Hr Days	57,600	28,800	19,200	9,600	64,500
5 8-Hr Days					15,360
Labour + Power Cost/Hr	.55	.45	.40	.33	2.30
Cost/M Parts	1.63	2.50	3.50	5.72	6.00
CAPITAL INVESTMENT					
Press	$20,000	$13,600	$12,000	$7,000	$16,000
Mold	8,000	6,000	4,500	1,600	9,000
Preformer (for 4 presses)					1,500
Preheater					1,500
Totals	$28,000	$19,600	$16,500	$8,600	$28,000

The labour cost for the automatics, from actual experience, will be based on 1/10th of an operator's time, @ $1.80/hr., whether he serves ten presses, or one press and does something else the rest of the time. The semi-automatic press will have its operator full-time, and his rate will be the same ($1.80/hr.).

The power requirements will be assumed to be electrical for both presses, at the rate of 2½¢/kwh. The hourly rate then would be:

		Power	Labour	Total
25-ton auto.	6kw	.15	.18	.33
50-ton auto.	9kw	.22	.18	.40
75-ton auto.	11kw	.27	.18	.45
150-ton auto.	15kw	37	.18	.55
200-ton str. ram	20kw	.50	1.80	2.30

The chart below shows that at a volume of less than 350,000 parts per year, the single-cavity, 25-ton automatic press can maintain that production at the same unit cost, and at a capital investment of 1/3 that of the semi-automatic press. Also, it occupies less than half the floor space. Savings not shown are the overhead of the small automatic spread over three shifts. For long runs, the 150-ton automatic press has the same investment cost as the semi-automatic 200-ton press, but tremendous savings in part-cost are indicated. It appears then, that savings will result from molding with automatic presses, either in equipment cost or in part price, no matter what size of run is required.

Only capital investment costs are included. Other operating expenses such as material cost, lubrication and maintenance labour and materials, set-up and repair labour, finishing costs, supervision and administration cost, and amortization rate will be quite different for the 24-hour operation than the 8-hour operation. Since semi-automatic presses sometimes are run on three shifts, these figures are eliminated from the comparison.

The efficiency of an automatic press running 24 hours a day is 95%. In the straight-ram press, the operator loses time blowing out the mold, opening the preheater tray for the preforms, reaching for the press close button, and other small delays. Therefore, the overall efficiency of the straight-ram press will be 80%.

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Photo courtesy Bergen Evening Record, Hackensack, N. J.

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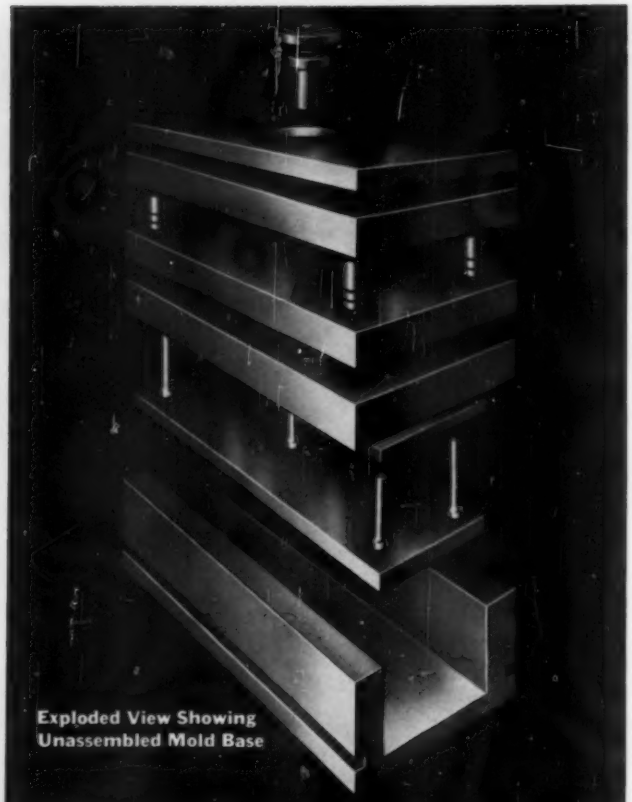
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MOLDMAKING

Spark Erosion Machining of Mold Cavities

A unique process for machining square, rectangular, triangular, half round, awkward, and oddly-shaped cavities.

Plastics moulds more than any other type, require more fine detail in their cavities. Finishes required are of a high standard containing generally many sharp corners and awkward contours. This is where Spark Erosion Machining will be appreciated.

The important advantage of spark machining is its ability to machine die steels and carbides, no matter what degree of hardness. The only requirement is that the work be conductive of electricity and that common sense be used in its application.

Examine the problem of making a mold containing a cavity with a ½" deep rib, .035" at the bottom, tapering up 1° per side for draft angle. To spark machine such a cavity presents no problem. All that is needed are four brass electrodes of the size and shape of the rib to be cut less a few thousands' a side for the spark gap. As no pressure is applied by the cutting action of the spark on "Mark III Sparkatron" no heavy clamping of the workpiece or the electrode is necessary. "It is virtually true to say that an electrode could be attached to the servo head with scotch tape and it would still cut an accurate hole."

Once the electrode is set in the correct location to the work piece, it is held in a slotted holder and retained by an allen screw. The operator selects the desired current and power settings, and switches on. The servo motor takes over and feeds the electrode to the work piece until it comes within the spark gap range which is determined by the settings in the control cabinet. Sparks will emanate from the electrode and the servo motor will halt its downward path. Each individual spark will remove a minute particle from the workpiece. As these sparks are jumping at the rate of thousands per second, one can appreciate the speed of metal removal.

Naturally, as metal is removed the spark gap will widen. The servo motor will then automatically advance the electrode to the correct spark gap, thereby creating a continuous cutting action.

The electrode will erode due to the plucking action of the spark. The wear ratio is usually 3:1 in favour of the electrode, hence the reason for four electrodes, which are changed at suitable intervals till the job is completed.

In many cases, the cavity is not processed any further, for the non-directional lenticular finish which is completely free of blemishes is well within the requirements of plastics mould manufacture.

Tunnel Gates

Sometimes it is found necessary to change the position of a tunnel gate sprue, after sampling, owing to the cavity not filling properly. Perhaps a core pin is restricting the flow of moulding material. This can be a problem in a hardened die and the answer would be to make several carbide tipped tools, or locally anneal the cavity. Both of these have their obvious drawbacks.

By employing Spark Machining, no change is made to the hardness of the die and the cost of relocating tunnel gates is considerably lowered. The average size required for tunnel gate holes is generally .050 tapering out 30° a side.

All that is required for Spark Machining is a piece of free machining yellow brass turned to a 60 degree inclusive taper with .050" dia. pip on the end. By way of interest, .004" dia. holes can be cut quite easily using .003" dia. tungsten filament wire.

Ejector Pin Holes

Quite often ejector pin holes have to be added to the already hardened die. Holes can be located in position within limits of plus or minus .001", and diameters of plus or minus .0005". The procedure is to rough out from the back of the core or cavity to within ½" or so of the shutoff face, with higher power settings, which give a larger spark gap, thus creating a slight taper of approximately .003" per inch. The final ½" is then machined parallel to facilitate correct location for the ejector pin.

Core Pin Holes

The same procedure as above is employed for core pin holes. Sometime it is necessary to move a core pin just a few thousands. Once again, Spark Machining is an advantage for it is no problem to make an oversize electrode relocate the centre of a hole and Spark Machine in the normal manner. For as explained earlier, there being no pressure applied between electrode and work on the unit, the electrode cannot "throw off", as would a milling cutter or a drill or even a boring bar.

Restoring Engraving

In hobbed cavities, raised letters and figures sometimes need the surrounding surface cut away .010" to .015", to make them more prominent on the component. By machining a piece of brass to the shape required, applying it to the cavity, and giving it a tap with a hammer, the letters and figures would then be transferred to the electrode. They would then be pantographed .015 deeper than the depth required in the cavity. In this way the electrode would not cut the letters but only on the surrounding areas which would need a light stoning only to obtain the required finish.

These are just a few of the applications where Spark Machining is of use. There are others, some of which are listed briefly: knurling; stipling; removal of broken taps, drills, reamers, and pins.

All of these can be performed with the die in its hardened state. The elimination of the fear of distortion after heat treatment is in itself a big time and money saver.

Spark machining is undoubtedly a big step forward in die making in this century. With this equipment, it is possible to "copy", the results of every machine that is normally used in a tool room.

—— ■ ——

Edited by **Ernest J. Csaszar**

Newark Die Co.

TECHNICAL MEETINGS CALENDAR

17th ANTEC

Annual Technical Conference—January 24-27, 1961, Shoreham and Sheraton Park Hotels, Washington, D.C. Sponsored by the Baltimore-Washington Section. General Chairman: Dr. Gordon Kline, National Bureau of Standards, Washington, D. C.

1961 RETECS

March 16—Plastics Finishing Seminar sponsored by Southern California Section with cooperation of Finishing PAG, Los Angeles, Calif. Chairman: Milton T. Schimmel, c/o Decorative Engineering and Supply Co., 17000 South Western Ave., Gardena, Calif.

April 4-5—Injection Molding Workshop sponsored by Pioneer Valley Section with cooperation of Injection Molding PAG, Holy Cross College, Worcester, Mass. Chairman: John H. Myers, c/o Foster Grant Co., Inc. 289 North Main St., Leominster, Mass.

April 20—Plastics in Buildings sponsored by Western New England Section with cooperation of Plastics in Buildings PAG, Springfield, Mass. Chairman: Robert W. Sherman, c/o Union Carbide Plastics Co., 410 Asylum St., Hartford 3, Conn.

May 9— Plastics in the Automotive Industry sponsored by Detroit Section with cooperation of Plastics in the Automotive Industry PAG, Detroit Mich. Co-Chairman: John A. McPherson, c/o Underground Products Inc., 12801 Inkster St., Livonia, Mich.

June 6—Plastics in Packaging sponsored by Quebec Section, Montreal, Quebec, Canada. Chairman: Ralph Noble, c/o Canadian Industries, Ltd., P.O. Box 10, Montreal, Quebec, Canada.

September 12—Plastics for Tooling sponsored by Central Indiana Section, Indianapolis, Ind. Chairman: Eugene C. Quear, c/o Delco-Remy Division, General Motors Corp., 2401 Columbus Ave., Anderson, Ind.

October 5—Plastics Foams sponsored by Buffalo Section. Section President: William Dunmyer, c/o The Carborundum Co., Building 71-1, Buffalo Ave., Niagara Falls, N. Y.

October 25—Plastics in Major Household Appliances sponsored by Kentuckiana Section, Louisville, Ky, Chairman: Ray E. Eshenaur, c/o General Electric Company, AP-5-249, Appliance Park, Louisville, Ky.

November 2-3—Plastics in Packaging and SPE Packaging Exhibition on Nov. 1, 2, 3 both sponsored by North Texas Section with cooperation of Southwestern Division of Society of Packaging and Handling Engineers, Dallas, Texas. Chairman: Peter Kent, 3637 Mid Pines Drive, Dallas 29, Texas.

November 15— Vinyl Plastics in the Household sponsored by New York Section with cooperation of Vinyl Plastics PAG, New York, N. Y. Chairman: Saul Gobstein, c/o Ferro Chemical Co., Box 607, Emerson, N. J.

December 1—Plastics Blow Molding sponsored by Cleveland Section with cooperation of Blow Molding PAG, Cleveland, Ohio. Section President: Jack Pecktal, c/o Eastman Chemical Products, 13212 Shaker Square, Cleveland 20, Ohio.

Offers of papers for presentation at these Regional Technical Conferences are invited. Please address offers to RETEC Chairman or Section President.

JOINT SEMINAR

March 15— Plastics for Tooling jointly sponsored by American Society of Tool and Manufacturing Engineers and SPE Casting and Plastics Tooling Professional Activity Group, Statler-Hilton Hotel, Detroit, Michigan. SPE Program and CPTPAG Chairman: Lawrence Wittman, c/o L. Wittman & Co., 1395 Marconi Blvd., Copiaque, N. Y.

SOUTHEASTERN NEW ENGLAND SECTION TECHNICAL PROGRAM

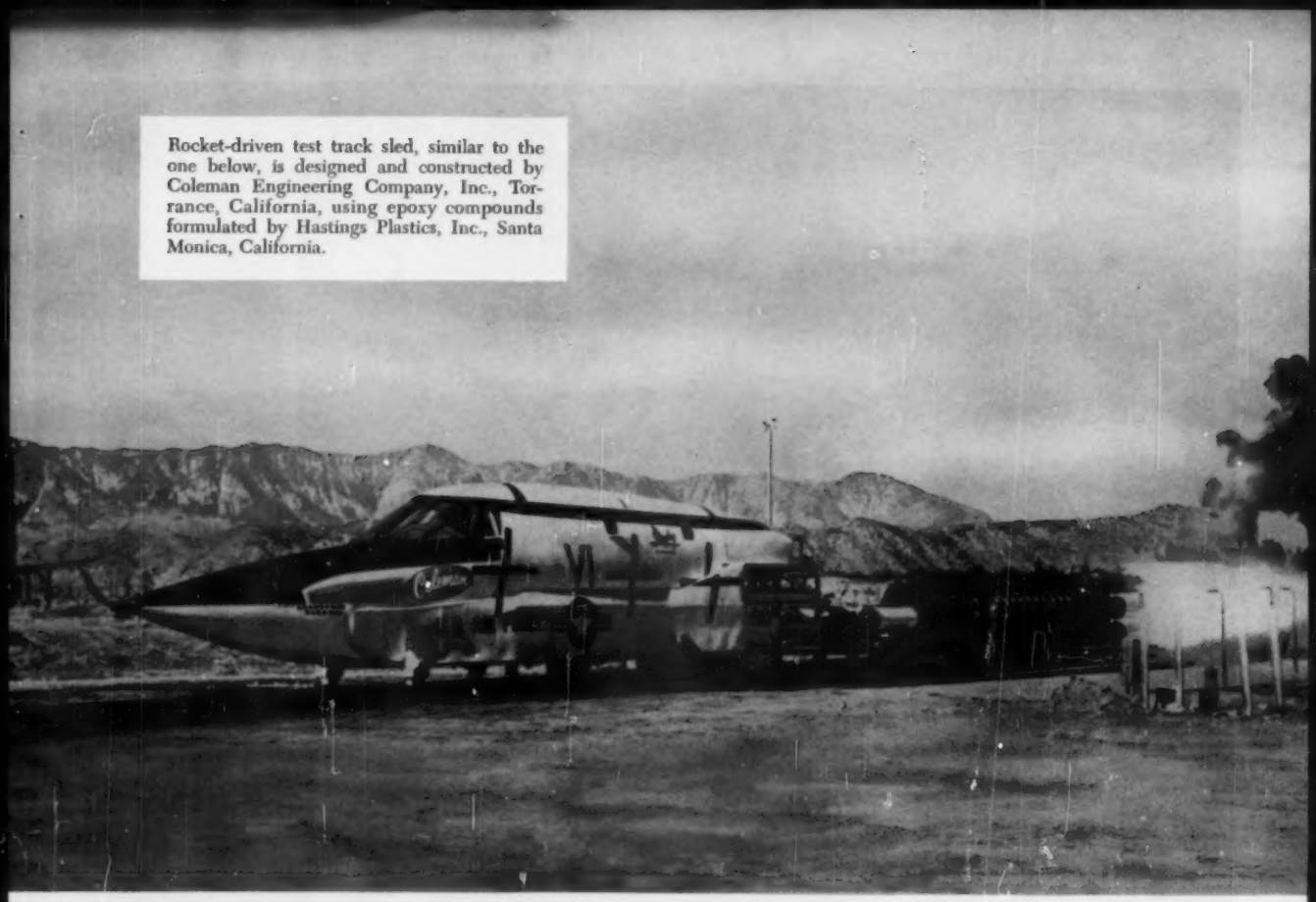
January 17—Plastics in Building Dr. Frederick J. McGarry, Associate Professor of Materials, Massachusetts Institute of Technology, Cambridge, Massachusetts.

February 21—Blow Molding Techniques Robert J. Boyden, F. J. Stokes Corporation, Stamford, Connecticut.

March 21—The Future of Thermoset Molding J. B. Lidstone, Specialist, Market Development, Phenolic Product Line, General Electric Company, Pittsfield, Massachusetts.

April 18—Thermal Consideration in Mold Design W. J. B. Stokes, Electromold Corporation, Trenton, New Jersey.

For information, contact Mr. Samuel N. Greene, Program Chairman, c/o Apex Tire & Rubber Co., Pawtucket, R. I.



Rocket-driven test track sled, similar to the one below, is designed and constructed by Coleman Engineering Company, Inc., Torrance, California, using epoxy compounds formulated by Hastings Plastics, Inc., Santa Monica, California.

Epoxies Pass the Test

AT SUPERSONIC SPEEDS

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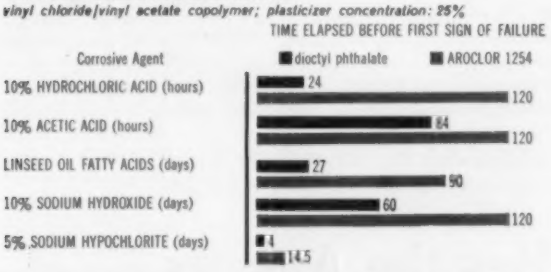
formulation	**control**	**modified**	**control**	**modified**
liquid epoxy resin	100	100	100	100
diethylenetriamine	13	13	...	...
phthalic anhydride	...	...	75	75
antimony oxide	...	5	...	5
DMP 30 (Rohm & Haas)	...	...	0.1	0.1
AROCLOR 1260	...	15	...	...
AROCLOR 5460	...	...	...	15
properties				
compressive strength, *psi*	43,000	38,150	23,400	40,700
flexural strength, *psi*	20,100	22,100	16,900	19,000
heat distortion, °C.	117.5	92	143	135
FLAMMABILITY—*inches per minute* (ASTM D635-56T)	0.82	NON-BURNING	0.6	NON-BURNING

EXTENDERS FOR PVC

Aroclors are especially effective as secondary plasticizers or extenders for polyvinyl chloride. Aroclor 1262, used 1:3 with dioctyl phthalate, sharply reduces migration to nitrocellulose lacquers. All Aroclor compounds can be used to improve the chemical resistance of vinyl chloride–vinyl acetate coating formulations.

TYPICAL CHEMICAL RESISTANCE*

vinyl chloride/vinyl acetate copolymer; plasticizer concentration: 25%



***Plotted from independent evaluation data by the Northwestern Paint and Varnish Production Club (The Official Digest, Nov. 1955). Conclusion: "The Aroclor 1254 had the best all-around chemical resistance."**

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Aroclor 5460 gives self-extinguishing, low-density polyethylene *with minimum effect on tensile strength or "memory."* Aroclor 5460 substantially improves heat stability, too, compared with other common flame retardants.

LOW-DENSITY POLYETHYLENE

formulation	**control**	**modified**
polyethylene	100	70
antimony oxide	....	10
AROCLOR 5460	....	20
properties		
melt index	1.96	6.2
% elongation	655	650
tensile strength, *psi*	2130	1710
yield strength, *psi*	1395	1300
FLAMMABILITY—*inches per minute*	7.1	SELF-EXTINGUISHING

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SPE JOURNAL

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OF PLASTICS ENGINEERING

Polyesters as Corrosion-Resistant Coatings

Lawrence Graubart
Reichhold Chemicals, Inc.

This article describes the formulation, application and testing of new heavy-duty polyester coatings for indoor, outdoor and corrosive chemical environments. These coatings are compared with several conventional commercial coating materials. The importance of proper surface treatment and prime coating is emphasized.

Oil-modified Polyester resins have been used as protective coatings for many years with varying degrees of success. Recently, the non-oil-modified Polyester, cured by Peroxide catalysts, has been investigated as a paint vehicle. Results of extensive testing indicate that this new vehicle has many advantages to offer from a protective stand-point over the oil-modified Polyesters commonly known as Alkyd resins.

Briefly, some of the advantages can be summarized as:

(1) Theoretically 100% film forming due to the reactive solvent used.
(2) Better chemical and water resistance due to the absence of fatty acid ester linkages.
(3) Good abrasion and weather resistance.

Due to the type of catalyst used, the paint is a 2-component system with its attendant pot-life. However, this limitation is easily overcome with the use of a 2-headed spray gun or a catalyst-injection system.

Applicators should be made aware of the effects of temperature and moisture on the curing of Polyester paints.

By comparing Polyester paints with conventional systems, it has been concluded that the multi-mil Polyester coatings have a definite place in the field of metal protection. Like all other systems, it is essential that good surface preparation be done prior to top-coating. Removal of foreign matter and corrosion products and a good primer to bond the finish coat to the sub-strate are required. It has been shown (1) that the useful life of a coating can vary from 1 to 7 years depending on surface preparation.

Four polyester resins were chosen around which to develop a high-gloss multi-mil coating and a lusterless multi-mil coating. These four Polylite* resins are designated as:

a. No. 8130—a flexible, isophthalic polyester resin
b. No. 8172—a resilient polyester resin
c. No. 8703—a non-air inhibited, gloss polyester resin
d. No. 8702—a non-air inhibited, gloss polyester resin

Primer Systems for Polyester Coatings

The first endeavor was to determine what surface preparation and primer system would give the best results on steel.

The following polyester gloss formulation was used as a top-coat over various primer systems tested.

FORMULA 1.

	Lbs.	
Rutile Titanium Dioxide	150	
Bentone 27	6	
Styrene	153	
RCI Polyester resin No. 8702	590	
RCI Polyester resin No. 8130	102	
6% Cobalt Naphthenate	4	
RCI—Flow agent ESL-1372	35	) Add just
RCI—Methyl-ethyl-Ketone-peroxide-60	7	) prior to use

Formula 1 was applied by spray 10-12 mils thick over solvent-cleaned steel and aluminum panels which were primed with one of the following systems:

a. Phenolated alkyd-iron oxide-zinc chromate primer
b. Epoxy—polyamide—zinc chromate primer
c. Epoxy ester—zinc chromate primer
d. Polyester primer (experimental)

* Polylite is the registered trade-mark of Reichhold Chemicals, Inc.

Table 1. Weatherometer (steel panels only)—360 hours exposure*

	Adhesion	Top Coat Chalk	Top Coat Gloss	Other Film Failure
a) Phenolated Alkyd	Good	None	Hazed	None
b) Epoxy-Polyamide	Excellent	None	Hazed	None
c) Epoxy ester	Good	None	Hazed	None
d) Polyester	Poor	None	Hazed	None
e) Control (No primer)	Poor	None	Hazed	None

* Equivalent to approximately one year exterior exposure.

It should be noted that all of these primers, except the polyester, are commercially accepted and that the purpose of the following tests was to determine which one of these primers worked best with a polyester top-coat, such as *Formula 1*.

The tests, which are summarized in *Tables 1 to 5*, were performed on the panels after they had air-cured for 7 days.

Weatherometer tests, *Table 1*, indicate that the epoxy-polyamide primer is superior to the others for adhesion to the metal under the conditions imposed. It was noted that the polyester top-coat *(Formula 1)* has a tendency to haze or become dull. The polyester coating showed weather resistance comparable to the commercial coating materials tested.

Table 2. Salt-spray (20%)—200 hours exposure (Panels scored)

Primer	Adhesion—Primer to metal		Adhesion Top-Coat to primer
a.) Phenolated Alkyd	Steel:	Good	Poor
	Aluminum:	Good	Poor
b.) Epoxy-polyamide	Steel:	V. Good	V. Good
	Aluminum:	V. Good	V. Good
c.) Epoxy-ester	Steel:	Poor	Good
	Aluminum:	Poor	Good
d.) Polyester	Steel:	Good	V. Good
	Aluminum:	V. Good	V. Good
e.) Control (No primer)	Steel:	Poor	— —
	Aluminum:	Poor	— —

Table 3. Impact Resistance (Steel panels only)

Primer	Direct-impact	Reverse-impact
a.) Phenolated alkyd	Pass 30"-lbs.	Pass 20"-lbs.
b.) Epoxy-polyamide	Pass 30"-lbs.	Pass 8"-lbs.
c.) Epoxy ester	Pass 30"-lbs.	Pass 8"-lbs.
d.) Polyester	Pass 30"-lbs.	Pass 8"-lbs.
e.) Control	Pass 30"-lbs.	Pass 8"-lbs.

Table 4. Sward-Hardness characteristics of Formula 1

Cure Time @ 77°F.	24 hrs.	120 hrs.	240 hrs.
* Sward Hardness	18	24	28

* Glass equal 100

Table 5. Chemical and solvent resistance of Formula 1

The top-coat was allowed to air-cure 4 days before it was exposed to direct contact, for 30 minutes, with the following reagents and solvents:

Reagent	Effect on Formula 1
50% H_2SO_4	V. Slight
25% H_2SO_4	None
25% HNO_3	None
50% HNO_3	V.V. Slight
50% HCl	None
25% HCl	None
50% HAc	None
25% HAc	None
10% NaOH	*Bad
5% NaOH	*Bad
Conc. NH_4OH	Bad
Acetone	**Sl. Removal
Ethyl acetate	**Sl. Removal
Toluol	**V. Sl. Removal
Ethanol	**V. Sl. Removal
Mineral spirits	**None

* Complete dulling at surface, but negligible film damage.
** Wet-rub after 10 minutes contact.

In the salt spray tests, *Table 2*, the epoxy-polyamide system appears to give the best bond to the substrate and to the top-coat (inter-coat adhesion).

The salt-spray test was repeated using a sand-blasted steel panel primed with the epoxy-polyamide primer. After 150 hours exposure, the panel showed no deleterious effects and gave much improved performance over the solvent-cleaned panels. There was very little rust creepage through the score and very slight blistering.

The data in *Table 3* indicate that *Formula 1*, regardless of primer used, lacks resistance to reverse impact. A good reading on impact-resistance is from 28-30" lbs.

Chemical and Solvent Resistance

Chemical and solvent resistance data in *Table 5* indicate that except for alkalis, the polyester coating was little affected by direct contact of concentrated chemicals. The sodium hydroxide dulled the surface quite a bit, but due to the thick coating, the substrate remained protected.

Conclusions of Primer Evaluations

Observations on *Formula 1* and the proposed primers indicate that if the steel surface is sandblasted and primed with an epoxy-polyamide zinc chromate primer, the polyester top-coat will give adequate protection to metal substrates.

Finish Coating System

After determination that the polyester coating was definitely showing promise, the next step was to compare it to several conventional and better known systems. Two polyester finishes were included, a gloss type improved over *Formula 1*, and a flat type. The comparison systems chosen were a) Melamine-alkyd baking enamel; b) Epoxy-polyamide enamel; c) long-oil length architectural enamel. These formulas are listed in *Table 6*.

All of the enamels tested (Formulas 3-7) were applied over sand-blasted steel panels previously primed with the epoxy-versamid primer *(Formula 2)*. In addition, *Formulas 3-6* were applied over cinder-blocks of the type generally

Table 6. FORMULATIONS OF FINISHES TESTED

Formula 2. Epoxy-Versamid Zinc-Chromate Primer: Air-Cure

	Lbs.
Component A:	
RCI-1425 Zinc Yellow	350
Desert Talc 54	50
Bentone 38	6
Xylol	144
M.I.B.K.	53
**Epotuf 6501-75	292
Component B:	
*Versamid 415	180
	1,075

Components A and B are mixed together ½ hour prior to use.

* Versamid is a registered trade-mark of General Mills Polyamides
** Epotuf is a registered trade-mark of Reichhold Chemicals, Inc. Epoxies

Formula 3. Air-Curing Gloss Polyester Top-coat

	Lbs.
Ti-Pure R-900	150
Bentone 27	6
Polylite 8703	530
Polylite 8130	175
1307-HV Beckosol	8
Styrene	153
6% Cobalt Naphthenate	4
Just prior to use add:	
RCI-ESL-1372 Flow agent	35
RCI-Methyl-Ethyl-Ketone Peroxide-60	7
	1,068

	24 hrs.	48 hrs.	1 week	2 weeks
* *Sward Hardness:*	8	14	20	20
Gloss:	97°			
Yellowness:	0.069			

* Glass = 100

Formula 4. Air-Curing Flat Polyester Top-coat

	Lbs.
325 Mesh Mica	50
Santocel 54	20
Rutile Titanium Dioxide	150
410 Mesh Silica	50
Polylite 8130	280
Polylite 8172	280
Styrene	152
6% Cobalt Naphthenate	2
2% Wax in Styrene Sol'n.	24
Prior to use add:	
Water	12
RCI-Methyl-Ethyl-Ketone-Peroxide-60	6
	1,026

	24 hrs.	48 hrs.	2 weeks
Sward Hardness:	4	6	6
Gloss:	2°		
Yellowness:	0.082		

Formula 5. Air-Curing Epoxy-Polyamide Gloss Enamel

	Lbs.
(a) Rutile Titanium Dioxide	250
Zinc Oxide	50
* 75% Epoxy solution	261
Methyl Isobutyl Ketone	84
Bentone 38	2
G.E. SR-82 Silicone	2
(b) ** Polyamide	131
Butyl Alcohol	49
Xylol	195
	1,024

Mix a and b together ½ hour prior to use.

	24 hrs.	72 hrs.	1 week
Sward:	16	22	22
Gloss:	99°		
Yellowness:	0.036		

* Epoxide equivalent: 450-525; Melt point 63-77°C.
** Amine value 210-220

Formula 6. Air-Curing Long-Oil Alkyd Enamel

	Lbs.
Rutile Titanium Dioxide	300
Bentone 38 }	3
Mineral Spirits } Pre-gel	25
Ethyl alcohol }	1
* 70% sol'n. Alkyd resin	510
Mineral spirits	145
6% Cobalt Naphthenate	3
24% Lead Naphthenate	7
4% Calcium Naphthenate	5
Anti-skin agent	1
	1,030

	3 days	4 days	10 days
Sward:	2	4	4
Gloss:	96°		
Yellowness:	0.069		

* Soya oil—65% on non-volatile
Phthalic Anhydride—24% on non-volatile

Formula 7. Melamine-Alkyd Baking Enamel (30' @ 250°F.)

	Lbs.
Rutile Titanium Dioxide	350
#1307-50 Beckosol	18
Xylol	155
Bentone 38	2
* 60% Sol'n. Alkyd resin	394
** 60% Sol'n. Melamine-Formaldehyde resin	175
Triethanol Amine	2
	1,096

Sward:	16
Gloss:	99°
Yellowness:	0.034

* Pure non-drying alkyd resin in xylol; Acid No. 2-5
** Melamine-formaldehyde resin in xylol-Butanol; Acid No. 1

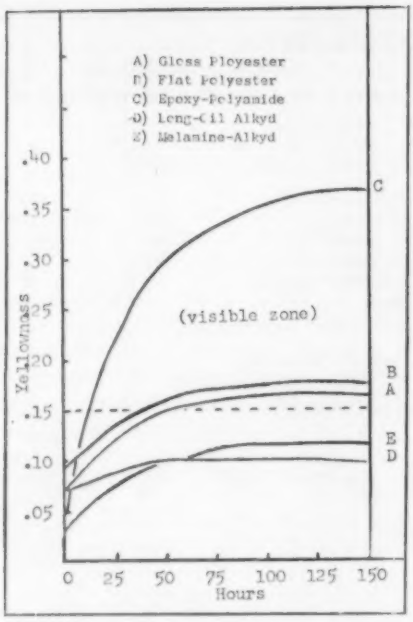

Figure 1. Panels exposed to yellowness readings. A yellowness reading of −0.0555 is white

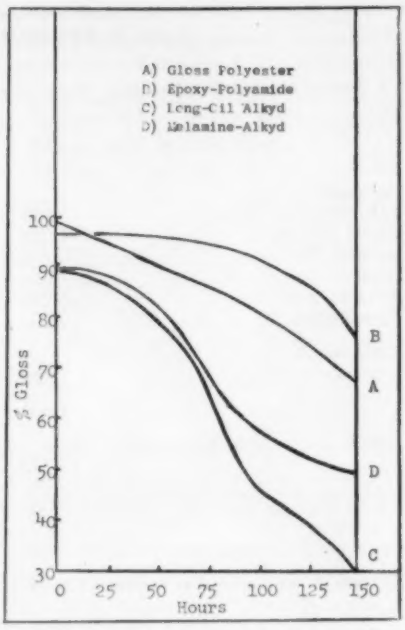

Figure 2. Gloss readings are based on a theoretical perfect gloss of 100%. Gloss polyester and epoxy-polyamide showed good gloss retention

Results of Yellowing due to U.V. Exposure (See Figure 1):

Enamel	Initial	Hours 25	75	125	150
a) Gloss Polyester (Formula 3)	.069	.126	.151	.161	.161
b) Flat Polyester (Formula 4)	.082	.141	.155	.155	.155
c) Epoxy-Polyamide (Formula 5)	.036	.218	.320	.346	.346
d) Long-oil Alkyd (Formula 6)	.069	.092	.081	.101	.090
e) Melamine-Alkyd (Formula 7)	.034	.068	.101	.112	.090

used in construction, to compare the paints as masonry coatings.

Ultra-violet Exposure: (Figures 1and 2)

Panels were exposed to concentrated ultra-violet radiation for 150 hours. Gloss readings and yellowness readings were taken at 25 hour intervals. This was a rapid test designed to show the gloss retentive properties and non-yellowing properties of each enamel and to compare them to one another. Theoretically, a yellowness reading of (−)0.0555 ···· is white. A reading of (+)0.140 to (+)0.165 is barely discernible to the eye while a reading of (+)0.200 is very yellow. Gloss readings are based on a theoretically perfect gloss (or reflection) of 100%. High-gloss enamels generally read between 85% and 97%.

It is noted from *Figure 1*, that all of the enamels with the exception of the epoxy-polyamide have good yellowing resistance. Also, it is noted that each class of resin has a characteristic curve—i.e., the alkyds are similar to each other as are the polyesters.

The gloss polyester and the epoxy-polyamide showed good gloss retention without visible hazing. The architectural and the melamine-alkyd enamels became badly hazed after 75 hours exposure.

Results of Gloss retention due to U.V. exposure (See Figure 2:)

Enamel	Initial	Hours 25	75	125	150
a) Gloss Polyester (Formula 3)	97°	94°	87°	75°	65°
b) Flat Polyester (Formula 4)	2°	2°	2°	2°	2°
c) Epoxy-Polyamide (Formula 5)	97°	97°	94°	80°	75°
d) Long-oil Alkyd (Formula 6)	89°	90°	66°	42°	30°
e) Melamine-Alkyd (Formula 7)	90°	91°	63°	57°	49°

Weatherometer: (See Figures 3 and 4)

Panels similar to those used in the ultra-violet exposure were subjected to 975 hours in an Atlas Twin-Arc Watercycle, Weatherometer.

The purpose of this test is to determine, in a rapid manner, the expected exterior durability of a coating. However, the best test for exterior durability is to actually expose panels to the weather and to wait patiently. This is also being done.

The Weatherometer exposure does afford a means of comparing films, hence the test was included in the series. Total of 975 hours exposure is theoretically equivalent to 30 months exterior exposure.

Visual observations of the panels show no signs of film failure at this time, such as chalking, blistering, rusting, checking, etc.

Comparing the data (*Figures 3 and 4*) shows that up to approximately 500 hours, all of the coatings lose gloss at essentially the same rate. It was noted that the Alkyd systems tended to level out at 500 hours while the Polyester and the epoxy continued to lose gloss. The epoxy showed loose chalking at 672 hours which became severe at 975

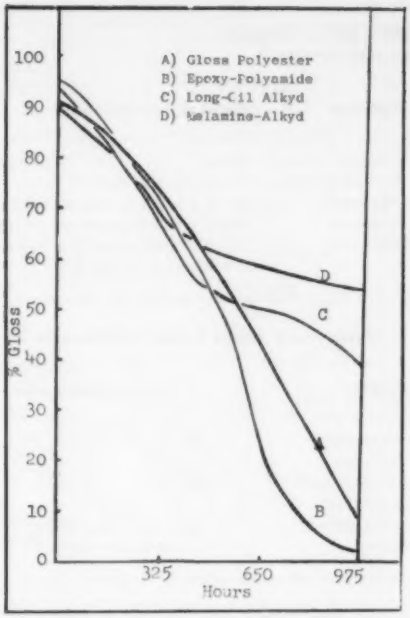

Figure 3. Gloss retention after exposure in Weatherometer

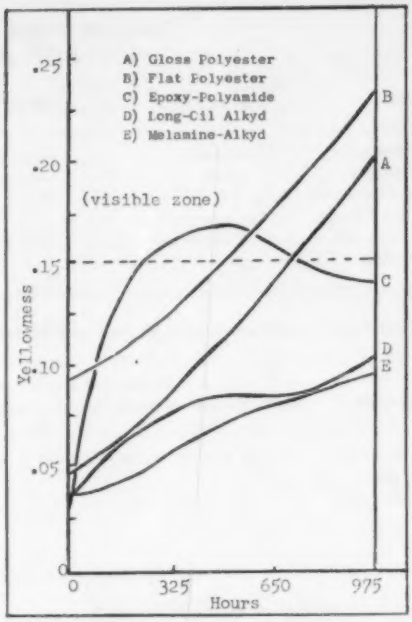

Figure 4. Yellowness readings after exposure in Weatherometer

Table 7. Gloss Retention (See Figure 3.)

Enamel	Initial Gloss	315 Hours	672 Hours	975 Hours
a) Gloss Polyester	93°	71°	33	8
b) Epoxy-Polyamide	97°	74°	15	3
c) Long-oil Alkyd	95°	64°	51	40
d) Melamine-Alkyd	91°	71°	60	55

Table 8. Yellowness (See Figure 4.)

Enamel	Initial Yellowness	315 Hours	672 Hours	975 Hours
a) Gloss Polyester	0.046	0.083	0.146	0.205
b) Flat Polyester	0.092	0.134	0.190	0.237
c) Epoxy-Polyamide	0.024	0.167	0.154*	0.139*
d) Long-oil Alkyd	0.035	0.072	0.073	0.101
e) Melamine-Alkyd	0.033	0.045	0.069	0.092

* Chalking

hours. The Polyester had a very tight chalk at the end of 975 hours.

Generally, all of the enamels have good film integrity after 975 hours.

Chemical Resistance Tests

Another function which a coating must perform, besides protection of the substrate, is that of resisting attack from the environment.

The five coatings were submitted to direct contact with various concentrated reagents, protected from evaporation by a watch glass cover for one hour. The coatings were then examined for chemical attack.

The polyesters have generally better acid resistance but poorer alkali resistance than the epoxy-polyamide. However, the alkali resistance of the polyester is of a higher order than the acid resistance (which is poor) of the epoxy-polyamide. The long-oil alkyd is generally deficient in resistance, while the melamine-alkyd bake system except for 50% nitric acid, is excellent. However, it is not possible to apply and bake melamine-alkyd systems on

Table 9. Resistance to Water and Detergents: Total Immersion
(Enamels were applied to sand blasted primed steel)

1) Panels were immersed for 8 hours in a 1% Tide solution @ 185°F.

Results:	Blister	Discolor	Soften	Adhesion
a) Gloss Polyester	Slight	Slight	No	Excellent
b) Flat Polyester	Slight	Slight	No	Excellent
c) Epoxy-Polyamide	Slight	Slight	No	Excellent
d) Long-oil Alkyd	Bad	Slight	Yes	Good
e) Melamine-Alkyd	Bad	None	Yes	Poor

2) Panels were immersed for 8 Hours in boiling water:

Results	Blister	Discolor	Soften	Adhesion
a) Gloss Polyester	Slight	Moderate	No	Excellent
b) Flat Polyester	None	Slight	No	Excellent
c) Epoxy-Polyamide	Moderate	Bad	No	Excellent
d) Long-oil Alkyd	Bad	Bad	Yes	Good
e) Melamine-Alkyd	Bad	None	Yes	Poor

Table 9a. 300 Hour Salt-Spray Test (20%) Brine):
a) Steel Panels, sand blasted and primed with Formula 2.

Top-Coat	Rust at Score	Blister at Score	Edge-Rust	General Appearance
1) Gloss Polyester	V.V. Slight	None	V. Slight at top	Good
2) Flat Polyester	V.V. Slight	None	V. Slight at top	Good, Sl. rust stain
3) Epoxy-Polyamide	1/32"-1/16" Creepage	1/4"-5/16" Creepage	Moderate	Mod. blistering over entire panel
4) Long-oil Alkyd	1/16" creepage	1/4"-5/16" Creepage	Moderate	Mod. blistering over entire panel
5) Melamine-Alkyd	1/32" creepage	7/16"-1/2" creepage	Moderate	Lg. blistered areas over entire panel
6) No coating	— —	— —	— —	Very severe corrosion

b) Steel Panels, not Sand Blasted, Primed with Formula 2.

Top-Coat	Rust at Score	Blister at Score	Edge-Rust	General Appearance
1) Gloss Polyester	V.V. Sl. Rust	None	None	Good
2) Other coatings not evaluated	— —	—	—	—

c) Aluminum Panels Primed with Formula 2:

Top-Coat	General Appearance
1) Gloss Polyester	Good
2) Flat Polyester	Good
3) Epoxy-Polyamide	Good
4) Long-oil Alkyd	Good
5) Melamine-Alkyd	Good; Sl. edge blister
6) No coating	Slight oxide coating

d) Aluminum Panels With No Primer:

Top-Coat	General Appearance
1) Gloss Polyester	Good; Edge blistered ¼"
2) Flat Polyester	Good
3) Epoxy-Polyamide	Considerable blistering at edge and score
4) Long-oil Alkyd	Several large blisters at edge and score
5) Melamine-Alkyd	Considerable blistering along score and edge

e) Steel Panels, Sand Blasted, no Primer:

Top Coat	Rust at Score	Blister at Score	Edge-Rust	General Appearance
1) Gloss Polyester	V.V. Sl. Rust	None	None	Good
2) Epoxy-Polyamide	1/16"-3/16"	None	Severe	Cons. blister throughout panel
3) Other coatings not evaluated	— —	— —	— —	—

f) Steel Panels, no Sand Blast, no Primer.

Top-Coat	Rust at Score	Blister at Score	Edge-Rust	General Appearance
1) Gloss Polyester	None	None	Slight	V. fine blisters over whole panel, delaminating
2) Flat Polyester	None	None	Slight	Good
3) Epoxy-Polyamide	1/32"-1/16" Creepage	1/4" Creepage	Cons'd.	Sv. lg. blisters over whole panel
4) Long-oil Alkyd	Film destroyed			
5) Melamine Alkyd	Film destroyed			

structural surfaces whereas it is a particular merit of the polyester systems that they can be job-applied.

The polyester coatings in general have a high order of chemical resistance as compared to other types of coatings and can be expected to perform well in most industrial atmospheres *Table 10*. Polyester coatings show good chemical resistance to many reagents harmful to metals.

Generally, the polyester coatings have good immersion resistance in hot water and detergent solution (*Table* 9). The epoxy-polyamide was not quite as good, while the two alkyd systems were poor.

Salt-Spray Tests (Table 9a, above)

It is generally conceded that one of the more rigid laboratory tests is that whereby coated panels are exposed, with an "X" scored through the film to bare metal, to a fine salt-spray mist at elevated temperatures. If a film can suppress corrosion from expanding outwardly from the score without itself lifting and blistering, it is doing well. Surface preparation is very significant in this test, as is priming.

Several conclusions can be made from this severe test. Primarily, it is noted, from the data, that the polyester coatings are exceptional in protecting the substrate due to their film thickness and highly cross-linked polymer structure. Of equal importance, it is noted that the long-oil alkyd and the melamine-alkyd completely disintegrated over the unprimed, non-etched steel surface. This was not true over a primed, sand blasted surface. All the other paints were also poorer over the improperly prepared substrate, serving to emphasize the necessity for good surface preparation prior to coating.

All of the enamels fared well when applied over primed (*Formula 2)* aluminum panels, but all, except the flat polyester coating, blistered over unprimed aluminum.

It was noted in comparing the coatings over bare steel versus bare aluminum what role the very nature of the substrate itself plays in the life of a paint film. The long-oil alkyd and the melamine-alkyd were completely destroyed over bare steel while they only blistered over bare aluminum.

Table 10. Chemical Resistance Tests

Reagent	Gloss Polyester	Flat Polyester	Epoxy Polyamide	Long-Oil Alkyd	Melamine-Alkyd
10% NaOH	CD, SL F De	CD, FI	NE	F De	NE
5% NaOH	CD, FI F De	CD, FI, SL Di	NE	F De	NE
Aqua-Ammonia(28%)	MD, FI	NE	NE	SL Di, FI	NE
Bleach	V SL Sp, FI	NE	NE	NE	NE
50% H_2SO_4	NE	NE	F De	SL Sp, FI	V SL S, FI
50% HNO_3	VV SL D, FI	V SL D, FI	C Di, F De	F De	F De
50% HCl	NE	NE	MD, MDi, SL D,	NE	NE
50% HAc	NE	NE	FI	NE	NE
50% H_3PO_4	VV SL Sp, VV SL S	NE	F De FI	V SL S, FI	SL S, SL Sp, FI
Lactic Acid(milk) —24 hrs.	NE	NE	NE	NE	NE
Citric Acid(juice) —24 hrs.	NE	NE	V SI Di, V SI D, FI	NE	NE

Key: NE—No effect SL—Slight M—Moderate C—Considerable D—Dulling Di—Discolored De—Destroyed F—Film S—Softened I—Intact Sp—Spotting V—Very

Impact Resistance

Coated panels, previously sand blasted and primed, were subjected to impact testing:

Results:	Direct Impact	Reverse Impact
a) Gloss Polyester	30"-lbs. Pass	8"-lbs. Pass
b) Flat Polyester	30"-lbs. Pass	8"-lbs. Pass
c) Epoxy-Polyamide	30"-lbs. Pass	30"-lbs. Pass
d) Long-oil Alkyd	30"-lbs. Pass	30"-lbs. Pass
e) Melamine Alkyd	10"-lbs. Pass	10"-lbs. Pass

On direct impact (Film concaves), all coatings are excellent except the melamine-alkyd. On reverse impact (Film convexes), the polyesters are poor while the melamine-alkyd is not much better. The epoxy-polyamide and the long-oil alkyd are excellent.

This test is meaningful only for steel objects which are apt to be deformed after coating.

Exterior Exposures

In June of this year, sand blasted steel panels primed with *Formula 2* and coated with each of the five enamels *(Formulae 3-7)* were placed on exposure racks in South San Francisco, California, and Miami, Florida. Additionally, construction type masonry cinder-block, coated with all but the melamine-alkyd baking enamel were placed on exposure in South San Francisco only. Polyester coatings of a type similar to those in this report have been exposed on masonry from 1 to 2 years and are showing no signs of failure to this date.

Reports in October from Miami, Florida on prototype gloss polyester coatings on steel were quite favorable with the exception of hazing as previously noted. Laboratory indications are that *Formula 3* has overcome this deficiency through the use of a new chloride-process titanium dioxide replacing the sulfate-process type.

Conclusions

This program was designed to develop some formulations based on non-oil modified polyesters, and to determine through controlled testing, both in the laboratory and in the field, the potential of these extremely versatile resins as protective and decorative coatings.

The evidence presented indicates that the pigmented polyester coating shows promise both for metallic and masonry surfaces. A room temperature, air-curing, chemical resistant coating capable of being applied as a low-shrinkage, multi-mil coating, has been developed.

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Table 11. Chemical Resistance of a General Purpose Polyester Vs Metals (2)

Reagent	Polyester	Carbon Steel	12 Cr. Steel	18 Cr.-8 Ni Steel	Monel
10% H_2SO_4	E	P	P	P	G
50% H_2SO_4	G	P	P	P	G
10% HCl	E	P	P	P	F
10% HNO_3	G	P	G	E	P
10% HAc	E	P	F	G	G
10% NaOH	F	E	E	E	E
50% NaOH	P	E	E	E	E
NH_4OH	F	E	E	E	P
NaCl	E	F	F	G	E
$FeCl_3$	E	P	P	P	P
$CuSO_4$	E	P	G	E	F
NH_4NO_3	E	F	G	E	P
Wet H_2S	E	F	F	G	G
Wet Cl_2	P	P	P	P	P
Wet SO_2	E	P	P	F	P
Gasoline	E	—	—	—	—
Benzene	G	—	—	—	—
CCl_4	E	—	—	—	—
Acetone	P	—	—	—	—
Alcohol	E	—	—	—	—

Key: E-Excellent, G-Good, F-Fair, P-Poor

Processing of Acetal Resins

P. N. Richardson

E. I. du Pont de Nemours & Co., Inc.

Calculation of melting and freezing rates helps in predicting processing behavior of Delrin

The melting and freezing of thermoplastic resins are basic processes encountered in plastics fabrication. A fundamental understanding of these processes and the ability to make predictions of processing behavior can be very helpful to the plastics engineer. Melting and freezing require the addition or the removal of heat and it is the purpose of this article to discuss the amount of heat required and heat transfer rates. "Delrin"® acetal resin is the thermoplastic chosen for discussion; however, the concepts considered are applicable to all thermoplastics.

Heat Requirements for Melting or Freezing

When an acetal resin is fabricated in a melt process, approximately 180 BTU of heat must be supplied to each pound of resin in order to raise it from room temperature through the melting stage and up to the desired melt temperature. This same 180 BTU/lb. must be removed from the resin when it is cooled from the melt to room temperature again. The heating and cooling process can be best visualized by the examination of a graph showing heat content versus temperature (*Figure 1.*). It is seen in this figure that there is a steady increase in heat content in going from room temperature up to about 350°F. This straight line section represents the increase in sensible heat. Slightly above 350°F, there is a rapid increase in the heat content at constant temperature as the polymer goes through a phase change (melting). Above the melting range, there is again a steady increase in the sensible heat of the polymer melt as its temperature is raised.

There are two main points of interest to be noted in *Figure 1.* First, there is a large change in heat content which accompanies the melting or freezing process, and second, there is a difference between the melting and freezing temperatures. "Delrin" is a crystalline plastic with approximately 75% crystallinity. During the melting process, this crystallinity is destroyed, and during the freezing process, the crystalline structure is formed again. The melting and freezing points are defined as the temperatures of maximum rates of melting and of crystallizing.

Another type of graph, which is based on the same data, is that of specific heat versus temperature. It shows more dramatically the heat requirements at the melting point (*Figure 2*). The curve shows a sharp peak at approximately 346°F which is the melting point of the resin. Other por-

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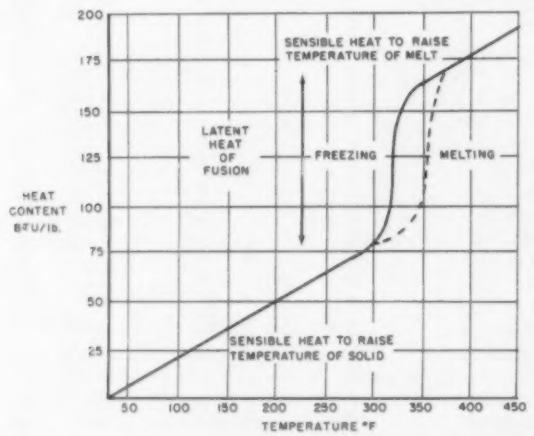


Figure 1. Heat content of Acetal Resin (Delrin). (Above reference temperature 32°F)

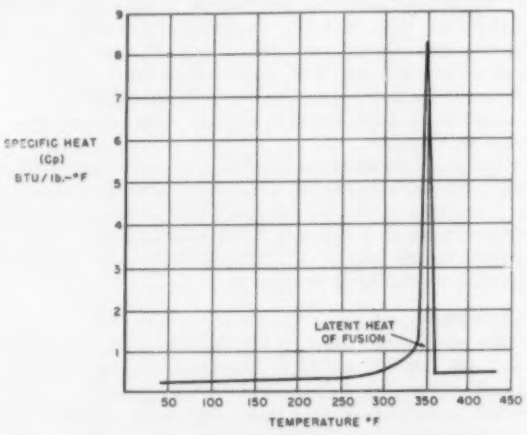


Figure 2. Temperature dependence of specific heat of Acetal Resin

tions of the curve are almost flat. It should be noted, that the data given in *Figures 1 and 2* and those which follow in *Figure 3*, were determined at very slow rates of heating compared to the rates normally encountered in plastics processing. The values are dependent upon heating or cooling rates; and therefore, in the practical case, some deviation from ideal behavior should be expected. This is especially true of melting or freezing points which are rate sensitive and can change 10-20°F.

In *Figure 2*, the area under the curve between any two temperatures represents the amount of heat which must be added to or removed from the resin in order to get from one temperature to the other. The area under the curve from 70°F to 410°F (room temperature and a common melt temperature) is approximately 180 BTU/lb. The area under the peak of the curve is the latent heat of fusion of the resin. This is the heat required to overcome the crystalline forces holding the solid together. In the case of acetal resin, the latent heat of fusion is 70 BTU/lb., and for melting 39% of the heat required is used in overcoming the crystalline forces at the melting point. It should be noted that this 70 BTU/lb. must be added to the polymer or removed from it in the melting or freezing range and not distributed over the entire temperature range involved. This becomes important when we consider the rate at which heat can be added to or removed from the polymer.

In any heat transfer system, the rate of heat transfer is proportional to the temperature difference between the material being heated and the heat source. When a resin is heated in an injection molding machine or an extruder, the cylinder or barrel temperatures are usually heated to about the same temperature as the desired melt temperature. Thus, in the case of acetal resin, the machines are commonly heated to 400°F. This is only 54°F above the melting point of the polymer, 346°F, at which temperature the 70 BTU/lb. heat must be added. To add this heat, the driving force (temperature differential) is only 54°F.

Now in contrast, when the resin is cooled from the melt, there is a much larger temperature differential between the freezing point at approximately 315°F and a quench temperature of 50 to 200°F. Thus, the driving force for removing heat is 115° to 265°F. Therefore, under the usual processing conditions, the resin is frozen faster than it is melted. As acetal resin is essentially rigid below its freezing point, this property of being able to be cooled rapidly has many advantages in polymer processing. In injection molding, mold closed times can be very short; and in extrusion, only short quench tanks are required. Many times it is found advantageous to use a hot quench in order to slow down the freezing process.

Comparison of the heat requirements for acetal resin with those for other thermoplastics can be made by the examination of plots of specific heat versus temperature (*Figure 3*). Data taken from the literature are given for low density polyethylene (1), high density polyethylene (2), 66 nylon (3), and polystyrene (4). Both the polyethylenes and nylon are partially crystalline polymers and thus, their curves are similar to that of acetal resin. These curves have peaks which show that there is a latent heat of fusion. On the other hand, the curve for polystyrene has no peak. It is a non-crystalline plastic; and, therefore, does not require heat to overcome crystalline forces. If a processing temperature for each of the resins is assumed, the amount of heat which must be added for processing can be determined from the areas under the curves. The results are given in *Table 1*. The heats of fusion are also listed.

It is seen from the table that both polyethylene and nylon require more heat for processing than acetal resin.

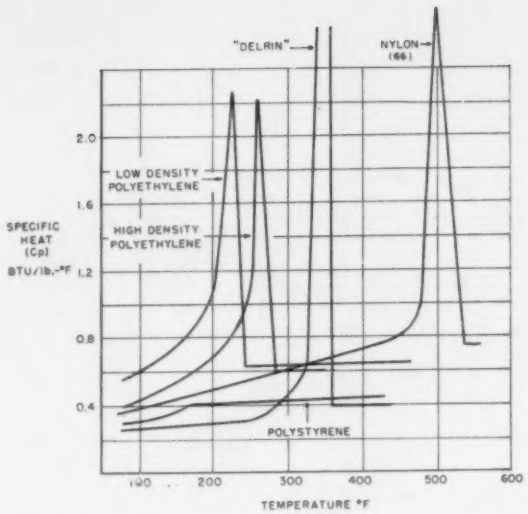


Figure 3. Temperature dependence of specific heats of Acetal, nylon, low density polyethylene, high density polyethylene, and polystyrene

Heat Transfer Rates

So far, only the quantities of heat required in plastics processing have been considered, and the rates of heating or cooling have been mentioned in qualitative terms. The remainder of this article is concerned with calculations of rates of heating or cooling.

The simplest case is one of steady state heat transfer. In this case, each point in the material conducting the heat remains at a constant temperature. This is the situation when heat travels through a material with the temperatures on both sides remaining the same. The following equation can be used for such calculations.

$$q = \frac{k A \Delta T}{L}$$

The rate of heat transfer, q (BTU/hr.), is calculated from the thermal conductivity of the material, k (BTU/hr./sq.ft./°F/ft.), area (A) (sq. ft.), and the thickness (L) (ft.) through which heat is transferred and the temperature difference ΔT (°F). An average value of k for acetal resin is 0.133 BTU/hr./sq ft/°F/ft.

This equation not only describes steady state heat transfer rates, but also serves as a basis for unsteady state heat transfer rate calculations.

There is another relationship we should have in mind before embarking on the main discussion, and that is the

Table 1. Heats Required for Processing

Resin	Processing Temperature	Total Heat Req'd BTU/lb.	Heat of fusion BTU/lb.
Polystyrene	500°F	160	0
Acetal Resin	400	180	70
Polyethylene Low Density	440	274	56
Polyethylene High Density	440	310	104
Nylon (66)	530	340	56

relationship between the amount of heat added to an object and its temperature rise. It is given in the following equations.

$$H = \int_{T_1}^{T_2} V \rho \, Cp \, dT$$

if Cp is a constant

$$H = V, Cp \, \Delta T$$

The quantity of heat H added to or removed from an object results in a temperature change ΔT. This temperature change depends upon the specific heat (heat capacity) of the material (Cp) and upon the quantity of material which is commonly expressed in terms of volume V and density ρ. In *Figure 2*, it was shown that the specific heat of acetal resin is not a constant, but varies with temperature. However, below the melting point, the value is almost constant (0.35 BTU/lb./°F).

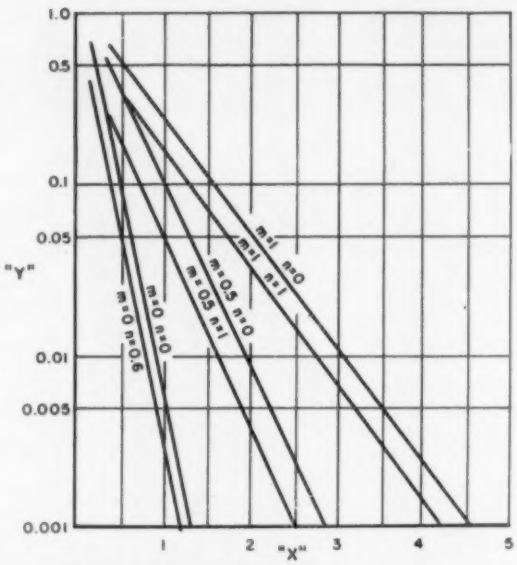
When an object is being heated or cooled, there is an everchanging temperature differential (ΔT) within the object; and thus, the equations to calculate the rates of heating or cooling become complex. Heat transfer under such conditions is said to be in the unsteady state because the temperatures at each point are continually changing with time. Under many conditions, it is possible to calculate the rates of heating and cooling, with the use of the convenient relationships published by Gurney and Lurie (5). Their relationships are plotted as a series of curves, which depend upon the geometry of the piece being heated, and involve four ratios. However, the method is restricted to a temperature range in which the heat capacity can be considered a constant. For acetal resin and other crystalline plastics, the method can be used only for heat transfer problems involving all solid or all melt. In these two cases, the heat capacity is essentially constant. One interesting and practical problem which can be solved with the use of Gurney and Lurie relationships is that of annealing rod stock. For example, how long should a piece of rod stock of acetal resin initially at room temperature, 4 inches in diameter, and 2 feet long, be allowed to stand in an oil bath at 305°F if we would like the center of the rod stock to reach a temperature of 275°F? The Gurney-Lurie plot for heating of cylinders is applicable to the problem, and a portion of this plot is reproduced in *Figure 4*. The plot is used with 4 ratios Y, X, m and n.

$$Y = \frac{T_s - T}{T_s - T_o}; \quad X = \frac{k \quad \theta}{CpR^2}; \quad m = \frac{k}{h_t \, R}; \quad n = \frac{r}{R}$$

Y is a reduced temperature variable. It has values between 0 and 1. "X" is a ratio taking into account both time and the properties of the material. m is the ratio of internal resistance to heat transfer to surface resistance; m can have values from 0 to ∞. n is a reduced position variable and can have values from 0 to 1.

The values and explanations of the symbols are given in the following table.

T_s	=	305°F Temperature of surroundings (oil bath)
T_o	=	75°F Initial Temperature of piece being heated.
T	=	275°F Temperature of point in question
k	=	.133 BTU/hr./sq.ft./°F per ft. Thermal conductivity
θ	=	heating time required (unknown)
ρ	=	89 lb./ft.^{3} density
Cp	=	0.35 BTU/ft./°F heat capacity
R	=	0.166 ft. radius of rod stock
h_t	=	100 BTU/hr./sq.ft./(°F) heat transfer coefficient between oil and surface of rod (will depend on the agitation of the oil)
r	=	0 ft. distance from the center line of the cylinder to the point of interest.



* Ind. Eng. Chem. 15 1170 (1923)

Figure 4. Gurney and Lurie* plot for heating and cooling cylinders

$$Y = \frac{30}{235} = 0.128 \quad m = \frac{.133}{100(0.177)} \approx 0$$

$$n = \frac{0}{0.166} = 0 \quad X = \frac{0.133\,\theta}{89(0.35)\,(0.166)^2}$$

From the graph X has a value of 0.42. $\theta = 2.70$ hours.

Through this problem, we have calculated that it takes 2.70 hours for the center piece of 4 inch rod stock of "Delrin" to reach a temperature of 275°F when it is heated in an oil bath maintained at 305°F.

The same types of calculations were carried out for both 2 inch rod and 4 inch rod, and the temperatures of the centers of the rods were calculated for various periods of heating. The results are plotted in *Figure 5*. This shows that heating plastic pieces is a slow process, and that it takes a great deal longer to heat a large diameter rod than a small one. The time varies as the square of the diameter. The heating times are long because the thermal conductivities of plastics are low. Values for other plastic materials would be similar as all thermoplastics below their melting range have similar values for their thermal conductivities and specific heats.

In *Figure 2* it was pointed out that the heat capacity of acetal resin changed abruptly during the melting process. Therefore, in order to calculate heat transfer rates involving both solid and melt, a special approach had to be devised. Previously it had been indicated that complex mathematical relationships were involved to develop the Gurney and Lurie method and the mathematics becomes much more complex when the heat capacity cannot be considered a constant.

It is beyond the scope of this article to discuss the mathematics involved in solving this problem. It has only been made feasible with the advent of high speed electronic computers. However, it is the purpose to present the practical results of this computer study. The results are presented both in graphical form and in the form of simple equations obtained by equation fitting to particular solutions of the exact differential equations.

Figures 6 and 7 show the rates of cooling which are predicted when a 2-inch diameter cylinder of molten resin is cooled in an environment below its melting point. These

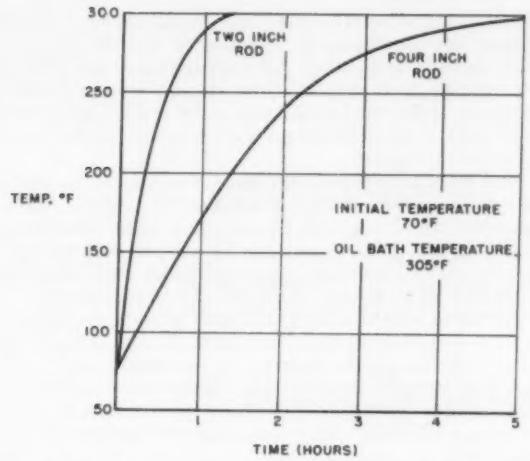


Figure 5. Center temperature of rod stock while heating for annealing

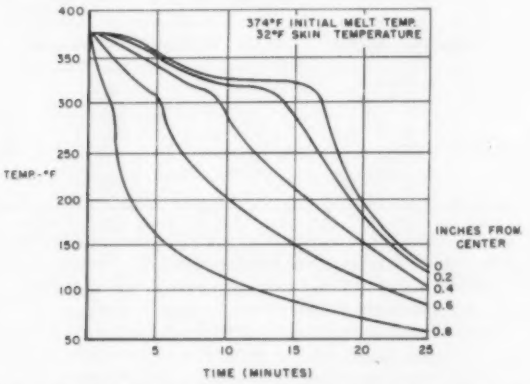


Figure 6. Cooling a two inch rod of Acetal Resin from a melt. (time-temperature profiles for lines of constant radius)

figures are applicable to the preparation of rod stock. In both figures, the initial melt temperature is the same, 374°F. In *Figure 6*, the cylinder is quenched with a medium at 32°F and in *Figure 7*, at 122°F. The series of curves on the graphs show how the temperature at points within the cylinder change with time. The figures show that the centers of the cylinders remain above the freezing point (315°F) for a long period of time. That is due to the large amount of heat (70 Btu/lb. the latent heat of fusion) which must be removed before it can freeze.

From a series of data, such as are shown in *Figures 6 and 7*, four equations were developed empirically which allow one to calculate melting or freezing times for acetal resin. These equations are listed below:

1) Melting a Cylinder—

The following equation is applicable for determining the time M(minutes) to melt the center of a cylindrical piece of acetal resin with a radius of R(inches). Two other factors also must be specified: the initial temperature of the piece (T_o) (°F) and the temperature of the outside skin of the piece (T_s)(°F).

$$M = 15.0\,R^2\,\frac{(336 - 0.5T_o)}{T_s - 352}$$

The use of this equation is restricted to values of T_s above 374° and to values of T_s below 257°F.

2) Melting a Slab—

The following equation is applicable for determining the time M(minutes) to melt at the mid plane of a slab of acetal resin which has a half thickness of (a)(inches). The definition of the other symbols is the same as for equation #1.

$$M = 30.3\,a^2\,\frac{(336 - 0.5T_o)}{T_s - 352}$$

3) Freezing a Cylinder—

The following equation is applicable for calculating the time M(minutes) to freeze the center of a cylinder of acetal resin which has a radius R(inches). Other values which must be specified are the initial temperature of the melt (T_o)(°F) and the temperature of the skin of the piece (T_s)(°F).

$$M = 7.7\,R^2\,\frac{(T_o + 252)}{316 - T_s}$$

The use of the equation is restricted to values of T_o above 374°F and to values of T_s below 257°F.

4) Freezing a Slab—

The following equation is applicable for determining the time M(minutes) to freeze the mid plane of a slab of acetal resin which has a half thickness of (a)(inch). The definition of the other symbols is the same as for equation #3.

$$M = 15.6\,a^2\,\frac{(T_o + 252)}{316 - T_s}$$

For all of the equations, it is noted that the T_s is the temperature of the outside skin of the piece which is being heated or cooled. This will be the same as that of the surroundings only if there is good contact between the heating or cooling medium and the resin.

Practical Applications

In the following discussion, melting and freezing times are considered in a few practical processing problems. The calculations help one to get a feel for the processes involved.

In work concerned with acetal resins, there has been a need for rod stock for machining of parts for end use testing. For the preparation of heavy rod stock, an understanding of the cooling rates was essential for the extrusion of good quality rod. The main problem to solve in making heavy rod is to make it void free in the center. This is done by continuously pumping additional resin into the center of the rod as the outside is being cooled. The rate of take-off of heavy rod is governed by two factors, the freezing rate of the rod and the ability to pump melt into the center of the rod. As rod produced by extrusion is cooled as it comes from the extruder, there is a cone of melt extending into the rod. In order to be able to pump melt into the center of

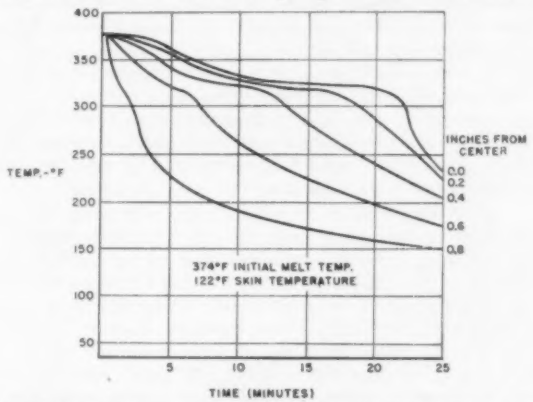


Figure 7. Cooling a two inch rod of Acetal Resin from a melt. (time-temperature profiles for lines of constant radius)

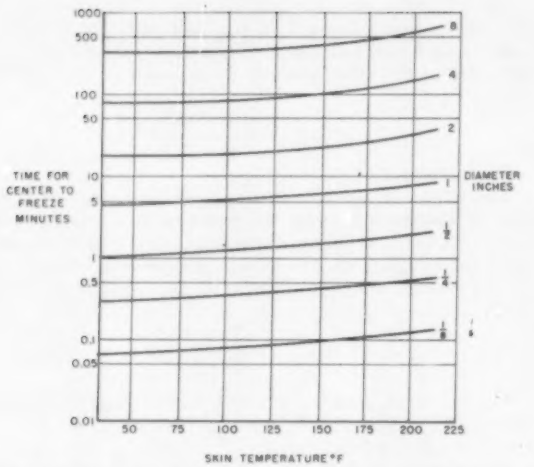


Figure 8. Freezing time for cylinders of Acetal Resins. (initial melt temperature 374°F)

the rod, the angle of the cone cannot be too small. If it is too small, the rod tends to freeze off and isolate areas which will subsequently contain voids. Through experience, it has been found that the cone should have an included angle in the neighborhood of 12°.

If it is assumed that 12° is a critical angle, then the length of a cone can be calculated for various diameter rods. For rods of 1, 2, and 4 inch diameters, the lengths of the melt cones calculate to be 4.75, 9.5, and 19 inches. It follows that the rods should be frozen in the center at these distances from the extruder in order to make void free rod. From *Figure 8*, it can be seen that 1, 2, and 4 inch rod can be frozen in 5, 20, and 80 minutes if it is cooled in surroundings at 50°F. It follows that maximum production rates are estimated to be 60 in./hr., 30 in./hr., and 15 in./hr. for 1, 2, and 4 inch rod stock. These estimates are in line with our experience in the laboratory.

It is also possible to make calculations of gate seal-off time in injection molding. The calculated values are subject to error because resin flows in the gate as it is being cooled, and the calculations strictly apply only to resin which is not moving. Also gates are often short and the equations apply to rods which are long compared to their diameters, and the temperature of the material in the gate is often unknown. Nevertheless, these estimates serve in helping to understand this part of the molding cycle.

Predictions of gate freeze-off times can be made from a study of Figure 8. A gate ⅛ inch in diameter would freeze-off in approximately 0.14 min. (8.4 sec.) with a mold at 212°F and in 0.065 min. (3.9 sec.) with a mold at 32°F. Of course, for larger diameter gates, longer freeze-off times are required. A gate ¼ inch in diameter requires 0.58 min. (35 sec.) to completely freeze in a mold maintained at 212°F. At a lower mold temperature, 32°F, the same gate would require only 0.28 min. (17 sec.) to freeze.

It is also possible to estimate the difference between the freezing time of a gate and the complete freezing of the molding. Let's assume a flat gear ¼ in. thick is filled through a gate ⅛ in. in diameter. Let's also assume that the temperature of the melt is 400°F and the temperature of the mold is 175°F. From equation 3, it is calculated that the gate will freeze in 8.4 sec., and from equation 4 it is calculated that the molding will totally solidify in 65 sec. In actual practice, the cure time in the mold can be shorter than this. Since the frozen outside skin of the resin is rigid, a molding can often be removed from a mold before it is completely frozen. In this way, it is possible to operate with extremely short cure times. Under such conditions, one should not be surprised to find the centers of thick sections of moldings still molten if they are cut open immediately upon removal from the mold. Some moldings produced under such conditions are of good quality, while other parts have to be completely cooled in the mold to be of acceptable quality.

One of the practical problems encountered in plastics processing, is the start up of extruders or injection molding machines which are full of resin. One often wonders just how long it is going to take for the resin to melt and to be able to start the machine. Large pieces of resin often have to be melted in extruder die parts and in the shooting cylinders of injection molding machines when a preplasticizer is used. Calculations were made with the use of equation 1 which applies to the melting of cylindrical shapes. The times to completely melt cylinders of various diameters which were initially at 70°F and were then heated in surroundings at 400°F were estimated. The results are given in *Table* 2.

Table 2. Melting Times Required for Cylindrical Pieces

Diameter—Inches	Melting Time, minutes
½	6
1	23
2	94
3	211
4	375

If the heat transfer equations are applied correctly the values obtained from them will be accurate. However, often in engineering practice, there are many values which are unknown and assumptions must be made. If the equations are used in such cases errors are to be expected; but even if the calculated values are in error, it is believed they can be helpful in understanding and solving processing problems. Some guesswork can be eliminated.

Conclusions

The heat required for processing acetal resin has been discussed and compared with values for other resins. It was shown that on the average less heat is needed for processing acetal resin than for either polyethylene or nylon. Rates of heating and cooling were discussed and equations were given that enable one to calculate melting and freezing rates of acetal resin. Practical applications involving the extrusion of rod stock and injection molding were considered.

Acknowledgments

The material in this paper concerned with the melting and freezing rates of acetal resin comes from a computer study carried out in the Research and Development Division of the Polychemicals Department. J. B. Lyon and F. C. Starr were responsible for these studies.

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Environmental Stress Rupture of Polyethylene

A simpler, more fundamental and more reproducible test of stress failure in solvent environments is proposed for polyethylene to replace the conventional Bent Strip Test

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The property of environmental stress cracking is a critical performance factor in the polyethylene product areas of wire insulation and both rigid and flexible containers. A realistic appraisal of this property, through an effective test method is vital to future product development as well as to a more precise selection of materials for various end-use applications.

Prior to the development of the Environmental Stress Rupture Test—which will be described here— testing methods were designed to evaluate cable insulating materials produced only in the 0.918-0.922 density range. However, as the range of polyethylenes broadened, some of the existing test methods were inadequate when applied to the medium and high density resins.

This deficiency pointed out the need to realistically ascertain the value of environmental stress cracking resistance of all polyethylenes on common basis.

Published information intimates that the phenomenon of environmental stress cracking while dependent upon the environment to which a material is exposed, is also a function of the level of stress. (1, 2, 3, 4.) It was felt therefore, that a test procedure incorporating a constant stress would provide the common basis by which to compare all polyethylenes. The Environmental Stress Rupture Test, developed by Union Carbide Plastics Company, Division of Union Carbide Corporation, provides a technique for determining the environmental stress rupture life of a material as a function of stress and temperature, using Igepal as an environment.

Previous test procedures for determining the environmental stress cracking behavior of polyethylene required the introduction of artificially induced stresses in the specimen. The test method more commonly accepted by industry to evaluate polyethylenes is the Bent Strip Test, developed by Bell Telephone Laboratories (4). Briefly, this test entails cutting a longitudinal slit into the center of a molded polyethylene plaque specimen. After the specimens are bent so that the slit will be on the outside, they are placed in a test tube 150 mm. by 18 mm., and the cracking agent is added, completely covering the specimens. The test cells are then stored at 50°C and frequent inspections are made for signs of cracking.

This test requires a high degree of exactitude in preparing the specimens. The critical nature is such that different personnel within the same laboratory might very well obtain widely divergent results. This feature coupled with the fact that the Bent Strip Test is not adequate for proper evaluation of the higher density resins, makes its use questionable as an accurate measurement of environmental stress rupture of all densities of polyethylene.

Also, if one is to study the onset or acceleration of brittle failures due to an environment, he should be able to control the stress level independent of the material being tested. With the Bent Strip Test, the stress level is a function of the stiffness of the resin. Therefore, the level of stress can not be arbitrarily set nor can resins of different moduli be compared directly. Also, the stress level does not remain constant throughout the test due to the stress relaxation properties of these materials.

In the Environmental Stress Rupture Test, a specimen is subjected to a constant tensile load in the presence of a surface-active agent such as Igepal. The specimens are either die-cut or machined from 0.040 inch thick plaque.

The specimen is the same as the "Type S Tensile Impact" specimen shown in *Figure 1*.

The apparatus which has been built to perform this test is shown in *Figure 2 and 3*. Made of aluminum for portability, the Environmental Stress Rupture Unit measures 32" x 15" x 10" and is capable of testing 20 specimens at one time. The tank containing the environment can be lowered to make the mounting of the specimens easier. An im-

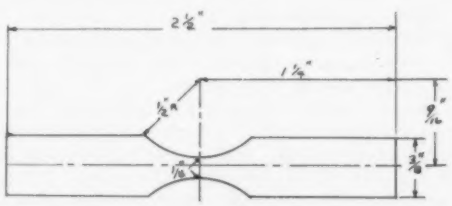

Figure 1. Type "S" tensile impact specimen

Figure 2. The Environmental Stress Rupture Unit with the tank lowered, showing the manner in which specimens are mounted

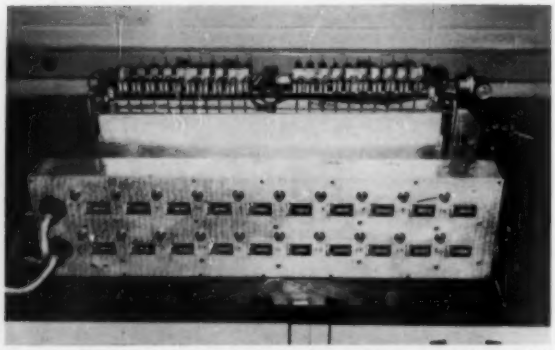

Figure 3. The Environmental Stress Rupture Unit with the tank in position and test underway. The box containing the timers is shown in the foreground

mersion heater is used to maintain constant temperature. The specimens are totally immersed in the environment and a constant tensile load is applied through use of level arms.

The failure of polyethylenes under these conditions is a sudden and complete fracture, hence, the term "environmental stress rupture". When the specimen fails the level arm falls shutting off an elapse timer, recording the life of the specimen to the near 0.1 hours.

The data collected on a material at any one temperature is plotted as stress versus the log of the time to failure. A curve obtained on a low density polyethylene at 60°C is shown in *Figure 4*. Here it is evident that the stress level is a definite factor affecting the life of the material in Igepal. This curve is typical for a low density polyethylene in that the life of the material does not improve substantially with decreasing stress at first. Ultimately, the curve does level out to a point where a small decrease in stress results in a marked increase in life. This leveling out of the curve gives rise to the belief that there is a stress level at which the low-density polyethylenes will last indefinitely in the presence of Igepal under stress.

Similar curves can be obtained at other temperatures. The curves in *Figure 5* show the effect of temperature on environmental stress rupture behavior of a high density polyethylene.

Correlation of Environmental Stress Rupture With Some Physical Properties

Considerable data have been compiled, using the constant stress procedure, at various temperatures and stress levels. This work was done in order to determine the ability of this type of test to correlate the physical properties of resins with their susceptibility to corrosive environments. Several polyethylenes were used covering a density range of 0.916 to 0.960 and melt indices from 0.3 to 20.0 dg/min.

The average molecular weight as measured by melt index is recognized as a dominant factor affecting the environmental stress cracking resistance of polyethylenes (7, 8). R. H. Carey has also shown that the average molecular weight affects the tensile strength of polyethylenes when tested in environments (1).

Five low density polyethylenes of about the same density (0.918) were tested to determine the effects of melt index on their environmental stress rupture life. The melt indices ranged from 0.3 to 20.0 dg/min. In *Figure 6* are the curves which were obtained at 60°C. Here it is plainly seen that melt index plays a major role in the environmental stress rupture behavior of these resins. There is a pronounced improvement in environmental stress rupture behavior associated with decreasing melt index. The effect of melt index appears to be logarithmic in that a large decrease in melt index from 20-8 dg/min. has resulted in only moderate improvement while a relative small decrease from 0.8 to 0.3 dg/min. has resulted in a marked improvement.

Three 0.950 density polyethylenes, covering approximately the same melt index range were also tested to determine the effect of melt index. These too exhibited improved behavior with decreasing melt index and again the effect seems to be logarithmic as can be seen in *Figure 7*. The overall effect of melt index, however, is not as pronounced as it is with the low density resins as can be seen by comparing *Figures 6 and 7*.

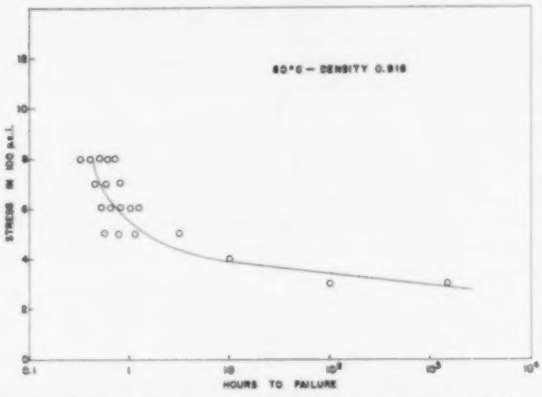

Figure 4. Tensile stress vs logarithmic time to failure for polyethylene immersed in surfactant at 60°C

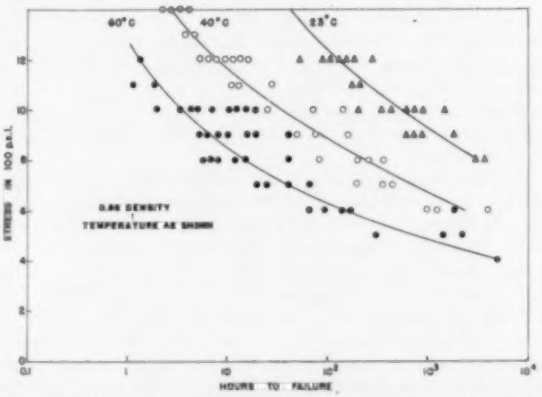

Figure 5. Stress vs failure time curves for polyethylene in surfactant, showing the effect of varying temperature of environment

Three samples of 0.960 density polyethylene were tested to determine the effects of melt index. Three samples were polymerized to melt indices of 1.0, 4.2, and 8.4 dg/min. *Figure 8* shows the data collected at 40°C.

The melt index obviously has little effect on the environmental stress rupture behavior of 0.960 density polyethylene over this range of melt indices.

The only group of polyethylenes, for which enough data have been collected to draw any conclusions as to the effects of density, is the low-density resins. The curves shown in *Figure 9* show the effect of density for two melt indices. These curves indicate that there is general improvement in environmental stress rupture behavior with increasing density. The degree to which the materials improve, however, is not consistent.

With the general improvement in environmental stress rupture behavior of low-density polyethylenes shown in *Figure 9*, one would expect that you would find a marked improvement in the .950 and .960 density range.

A comparison of the environmental stress rupture behavior at 60°C of each density range shown in *Figure 10*, however, does not bear this out. This figure represents the spread in environmental stress rupture life found in each density range. Except for the high melt index, low-density resins, the stress level at which polyethylenes will last for an indefinite time in the presence of Igepal is of the same order of magnitude regardless of density.

Igepal greatly accelerates the brittle failure of low-density polyethylenes when under stress. There are indications,

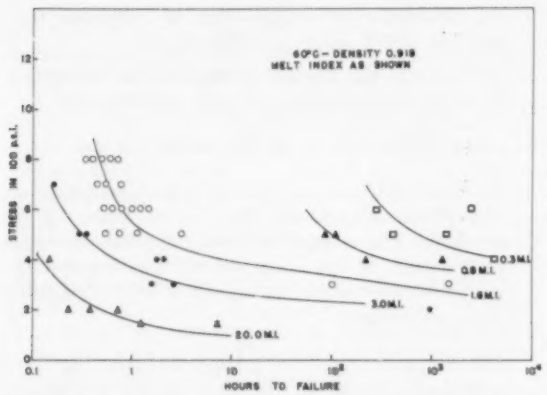

Figure 6. Comparison of stress vs time to failure curves for five low density polyethylenes

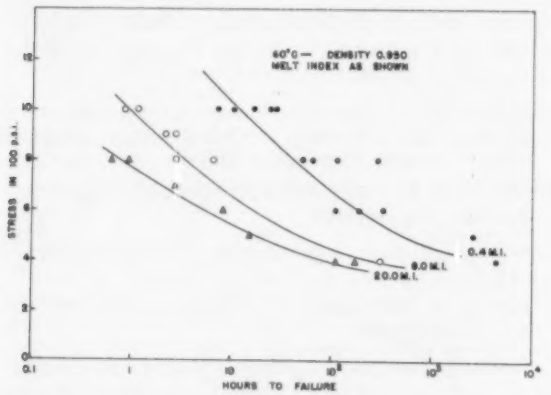

Figure 7. Stress vs time to failure curves for high density polyethylenes of melt index similar to low density polymers in Figure 6

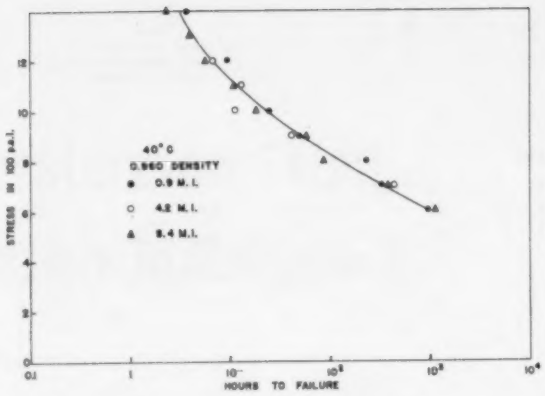

Figure 8. Stress vs. time. Note small effect of melt index on time to failure of high density polyethylene

however, that the Igepal environment is not nearly as effective on the .950 and .960 density resins.

To illustrate the difference in susceptibility of these resins to Igepal, various specimens were tested without Igepal at 600 psi and 60°C. The lives of these resins in air were then compared to the data collected by the environmental stress rupture test. Both of the low-density resins tested lasted for more than 1,000 hours in air as compared to a mean life of 0.4 hours and a maximum life of 1.0 hours when tested in Igepal.

Both the .950 and .960 density resins, however, had lives in the same order of magnitude in air and Igepal.

The following are suggested tests for determining and comparing the environmental stress rupture resistance of all polyolefins on a common basis.

The environmental stress rupture resistance of all polyolefins can be compared on a common basis by comparing the mean life of each material when tested under the same conditions. The choice of the temperature and stress level to be used for comparison is arbitrary. Experience, however indicates that 600 psi at 60°C is a good set of test conditions. At a higher temperature or stress level, the high melt index polyethylenes will fail by elongating. At a lower temperature or stress level, some resins will last too long

Table 1 Properties Comparison of the Environmental Stress Rupture Life of Several Polyethylenes at 600 psi and 60°C.

Resin Type	Density	Melt Index	Life at 600 psi and 60°C
1	0.914	1.8	0.2
1	0.919	0.3	350.0
1	0.918	0.8	60.0
1	0.918	1.6	0.7
1	0.917	3.0	0.2
1	0.917	20.0	0.1
1	0.919	3.0	9.0
2	0.927	1.4	120.0
2	0.928	3.0	20.0
2	0.930	16.0	0.7
3	0.948	0.4	170.0
3	0.950	8.0	20.0
3	0.950	20.0	5.0
3	0.960	1.0	250.0
3	0.960	4.2	250.0

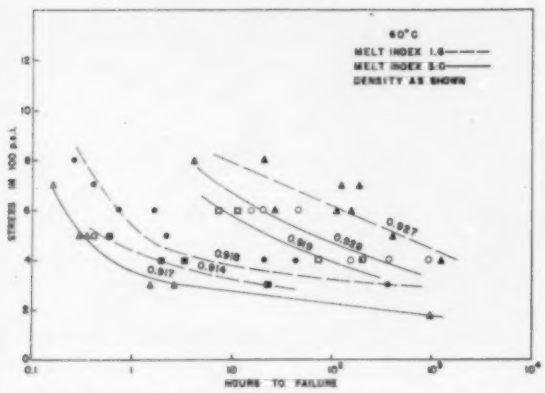

Figure 9. The effect of density on time to failure in the low density range

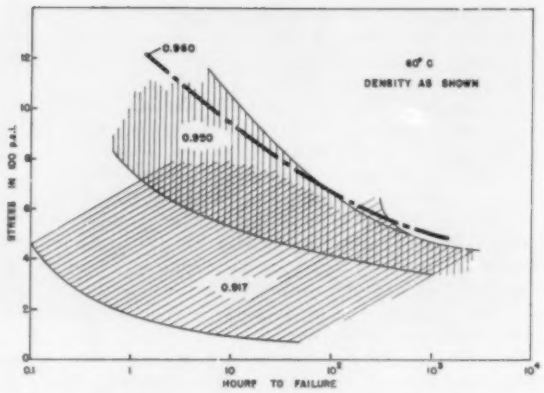

Figure 10. General range of environmental stress rupture curves for polyethylenes of various densities at 60°C

for the test to be practical—more than 2,000 hours. Included in *Table 1* is a tabulation of the mean life at 600 psi and 60°C of several polyethylene materials. These resins had mean lives ranging from less than 0.1 hours to 350 hours. Some individual specimens which have been tested under these conditions have lasted as long as 2,000 hours. This gives a large range in which to rate the environmental stress rupture resistance of all polyolefins.

Testing Procedure for Evaluating New Resins

Whenever a new resin is developed, it should be tested at several stress levels and temperatures. Then, curves similar to that depicted in Figure 5 can be plotted at each temperature. This gives a comprehensive picture of how the material behaves. It includes an indication of the stress level, if there is any, that the material will withstand for an indefinite period of time. These curves would also show the effect of temperature on the environmental stress rupture properties of the resin.

Development Test for Use as a Development Tool

This test would be used to determine the effects of minor changes in processing or composition. The test conditions should be such that data can be obtained within a reasonable length of time. A single set of conditions, for example, one temperature and stress level, would not give results within a reasonable length of time for all resins. Listed below are five sets of conditions.

a. 60°C at 200 psi
b. 60°C at 400 psi
c. 60°C at 600 psi
d. 60°C at 800 psi
e. 60°C at 1,000 psi

The set of conditions to be used for a particular material are to be chosen so that the mean life of the material falls between 1 and 500 hours. Once the choice has been made, the material will always be tested under the same conditions. The degree of improvement or degradation due to minor changes can then be compared directly.

Summary

In summation, a constant stress type of environmental test is felt to be a more fundamental test. It should be an extremely useful tool in that it will enable the:

1. Comparison of the environmental stress rupture behavior of all polyethylenes on a common basis.
2. Determination of the stress level (if any) at which a resin will last indefinitely.
3. The direct comparison of the environmental stress rupture and stress rupture properties in air.
4. The determination of the effects of stress and temperature with a variety of environments.
5. The study of the mechanism effecting the susceptibility of thermoplastics to corrosive environments.

It is also felt that the test is very versatile in that:

1. The test need not be run on special equipment. Much of our earlier work was done by dead loading the specimen. The environment was maintained by wrapping a piece of felt about the reduced section. The specimens were placed in an oven when testing above room temperature.
2. This test is not restricted to polyethylenes. Rigid and semi-rigid materials may be tested by this method.

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Effects of Temperature on Filled Epoxy Encapsulation Materials

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Voids are an annoying problem in epoxy resin encapsulating operations. Because of their varied locations, voids are attributed to conflicting sources: faulty mold design allowing air to seep across mold lands during material shrinkage; exothermic curing reaction releasing dissolved air; or inadequate deaeration period. A fresh viewpoint in attacking the problem of their formation is needed.

Experimentation

Keeping in mind that mold design and void formation could be related, a resolution was made to encapsulate under air-tight conditions; and in order to see what occurs, a one-liter beaker, Griffin type without a spout, was used.

A flat surface was honed on the lip so that a smooth glass plate could fit across the top and, when sealed properly, would not permit air to pass at the sealed surface. The beaker and glass plate were cleaned and dried, but were untreated with mold release. A mixture of epoxy (100 pbw), metaphenylene diamine (14 pbw) and mica (100 pbw) was prepared, evacuated for four minutes, and then poured into the beaker to a depth that left a thin air space between the glass plate and the top of the material. The ground lip was coated thinly with the encapsulation mixture and the glass plate fitted. The unit was placed on the lowest shelf in a forced convection oven, whose air currents flowed vertically upward, to cure at an oven temperature of 135°F.

Frequent observations were made during the gelation period. While shrinkage developed at the surface of the material, the glass plate was slowly compressed inward and began to flake in concentric layers from its center towards its edge. Meantime, on the radius at the bottom of the solidifying mass, and about 60° apart, six voids formed inward for a short distance toward the center of mass of the material. Since the voids began to appear at the time the cover was flaking and before fracture of the beaker occurred, we had evidence that an air-tight mold produces its void by shrinkage during the gelation period (*Figure 1*).

Next, a large steel production mold associated with frequent void formations was selected for further study. Normally the mold held a large thermally sensitive electronic assembly, but during much of our study castings were made without the assembly. About nine pounds of epoxy-mica-diethanolamine, in a 50-50-6 ratio respectively, was used to fill the mold. The mixture was evacuated at 1-3 mm. mercury, absolute, for two minutes before pouring and again for 25 minutes, an unusually long deaeration period, after filling the mold in order to reduce the dissolved air. Then the filled mold was placed in a forced air oven in which air moved laterally, to cure at 130°F ambient temperature throughout the gelation period.

Shielding molds reduces heat losses and prevents formation of voids

Several castings were made, but on each voids were found along the mold line and at bottom corners or on the radii between corners (*Figure 2*, Unshielded Unit). However, during cure of the castings it happened that a vertical air flow oven was used, and as we studied the voids afterward, the direction of flow of the oven air currents seemed to be related to the void characteristics.

Consequently, with further evidence needed, several small glass beakers were filled with a fresh mixture and placed in forced air ovens, one having vertical upward flow air currents and the other a horizontal movement of air. Examination of void characteristics of these clearly related them to the flow pattern of the oven air currents. Since experimentation with encapsulations unprotected from the cooling effects of oven air currents had produced voids, a series of shielded encapsulations for additional study was made.

In this study experimental units were placed inside larger glass beakers upon an insulator to form an air space about the experimental units. Each control consisted of an identical filled beaker placed nearby on the oven shelf and in a moving air temperature of 130°F. After curing the shielded

Figure 1. An air-tight mold produces its voids by shrinkage during the gelation period

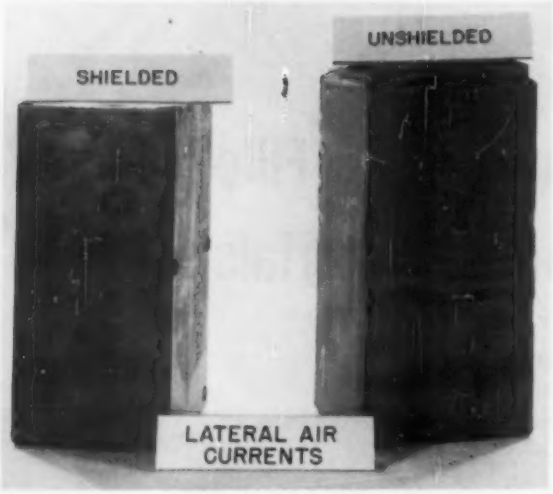

Figure 2. Photograph shows how shielding cuts down on void formation

Figure 3. The shieldment is a portable structure with an aluminum outer-shell and a middle layer of one-inch thick glass matting, laid upon an inner surface made of copper cloth

encapsulations were found to be solidified into a smooth, uniform mass, in contrast to the controls which had developed voids peculiar to the type of oven air currents in which they were used (*Figure 3* shows similar effects).

Shielding

Following this study, the steel mold was again used to determine whether similar results would be obtained if it were shielded. At first, the mold was covered with two layers of insulating glass mat, but voids developed as usual. Since the matting appeared to be an unsatisfactory shield against the cooling effects of the oven air currents, a shieldment was designed and made, large enough to protect the mold. The shieldment was a portable structure with an outer aluminum shell, matting, and an inner surface made of copper cloth (*Figure 3*).

Employing the shieldment, we found that a series of encapsulated units solidified voidless, while the controls formed voids. Controls were identical unshielded units cured in the currents of the oven, positioned beside the shielded experimental unit. Also, it was ascertained that shielded units developed smoother surfaces (*Figures 2 and 3*).

Miscellaneous Observations and Discussion

During gelation an inversion of an epoxy-mica mixture occurs in which top strata descends to lower levels, while lower strata solidifies near the upper surface. This phenomenon was easily seen in a 7 x 7 x 16 inches mold made with glass sides. Small amounts of different epoxy dyes were placed at top and bottom edges of the material with a pipette, followed by cure in a 130°F oven without the shieldment. Dye movement was readily followed on the material surface until gelling was complete. The block was sectioned and the internal locations of the dyes determined. In general, the central core of material flows upward while the outer layer descends.

Also noted was the faster cure of material gelling in cylindrical molds at their upper level, effectively forming an air-tight mold below the cured surface. As the cure proceeds to lower portions of the mass, there is a shrinkage from the liquid phase at the periphery of the material inward toward the solidifying core. Voids are produced at those points in the cooler liquid mixture, especially at the edges and corners of the mass, where the ratio of mold surface area to material volume is higher than at the mold faces. Incidentally related perhaps are those voids which can be found by X-ray examination, that lie adjacent to the interior wall of a form that serves as a permanent mold.

Frequently, in large castings, a reservoir of material is poured above the finish height of the product in order to overcome void formation. In some instances the practice arises from a belief that during shrinkage the necessary material to prevent voids is pulled from the reservoir. Our study disclosed that a slump occurs at the corners of the material in the reservoir, but this happens for the same reason that voids occur at edges and corners at the base of the material. The coolest material solidifies last, whether it is at the top edges or corners of a reservoir, or at the lower mold extremities. One can see the characteristic at the corner of the unshielded block in *Figure 2*.

Pouring the reservoir is unnecessary and costly because it entails machining the excess material after curing. If the mold surface temperature can be uniformly controlled, such as by a portable shieldment, mixture solidification is more uniform because the temperature difference at points between the central core and the peripheral material is lessened. In a sense, the mixture produces heat needed to partially cure itself initially, and while the shieldment is actually an effective barrier for loss of heat from the curing mass, it also serves to promote uniform temperature about an encapsulate. Similar results were obtained by placing experimental units at the highest levels in vertical air current ovens, though oven temperatures were kept at 130°F.

Lastly, where thermally sensitive components are to be encapsulated, caution must be exercised if the components cannot withstand the higher temperature produced by the use of a shieldment.

Summary

Voids form in vacuum conditions. Cooling effects differ on the surface of a mold in relation to the surface area of the mold and the volume of material producing heat. Shielding a mold reduces heat losses and prevents voids, as well as improves the surface finish of filled epoxy castings.

Melt Index Equivalent — A New Flow Parameter

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Introducing a method of predicting the effect of differing molecular weight distributions on polymer properties

The end properties of polyethylene are governed to a large extent by crystallinity (density), molecular weight, and molecular weight distribution. Although we have some concept as to the effect that molecular weight and density exert on the basic properties of polymers, it is difficult to understand or appreciate the full significance that molecular weight distribution has on these same properties because of the rather complex relationship which exists between these molecular parameters. An attempt will be made, however, in this paper to explore some of the more obvious ways in which this parameter influences polymer performance. In addition, a test method will be proposed which should offer a suitable means for the characterization or resins and can also be used as a quality control method to insure resins of controlled uniformity.

The melt index, which is a measure of the fluidity of polymers under low shear rates, has been generally used as a basis for comparing the relative flow characteristics of polyethylene resins. With polymers made under identical processing conditions or exhibiting similar molecular weight distributions, the melt index can provide vital information not only in regard to the ultimate processability, but can also provide a relative indication on those properties dependent, to some extent, on melt index (molecular weight), e.g., impact strength, environmental stress cracking, etc. However, when this test is applied to polymers made under different processing conditions, the relationship between melt index and certain properties is often misleading. This is illustrated in *Table I* where the physical properties of the experimental type linear polyethylene resins of similar density and melt index are presented. The dissimiliarity of certain physical properties between these resins may be attributed to difference in molecular weight distribution.

From the above data, it appears that the processability, as well as other properties, are not only dependent on molecular weight but also on the type of distribution. Consequently, melt index should not be employed as the sole basis of comparing resins that are known to contain different distribution. It should not be concluded from this statement, however, that melt index is no longer a useful test for quality control work involving polymers of the same distribution. It is only in comparing polymers with different types of distributions that this test loses some of its significance as a measure of the relative performance of polymers.

Rotational and extrusion viscometers have been used quite extensively for characterizing the flow behavior of plastic materials. Studies with such instruments have shown that resins possessing a broad molecular weight distribution will generally possess less flow at low rates of shear (those commonly employed in melt index determinations) than compared to polymers with a narrower molecular weight distribution. As the shear rates are increased, the flow re-

Table 1. Comparison of Polymers on the Basis of Similar Melt Index

	ASTM Method	Experimental Resin "C"	Experimental Resin "D"
Density	D1505-57T	.960	.960
M.I.	D1238-57T	10.0	10.0
Flow Index	—	29.9	9.6
Spiral Flow, gms.	—	10.2	6.7
Tensile Strength, psi	D638-58T	4340	4250
Elongation, %	D638-58T	5	20
Stiffness, psi	D747-58T	168,000	171,000
Impact, ft-lbs. (notched)	D256-56	.46	.95
ESC, F_{50}, hrs.	—	BOB*	1
Brittleness Temperature, F	D746-57T	+80	−180

* Broke on Bending

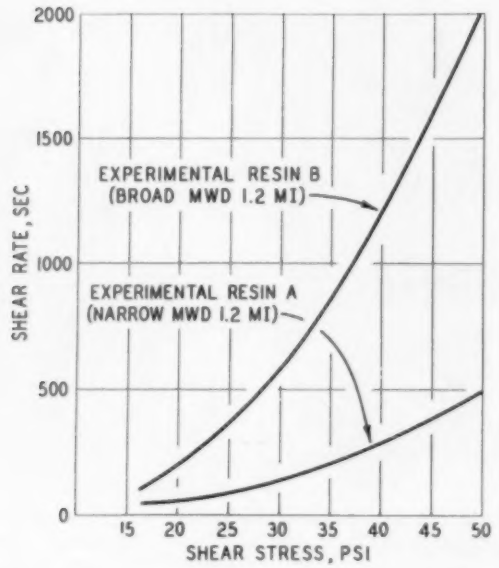

Figure 1. Effect of molecular weight distribution on polyethylene flow response

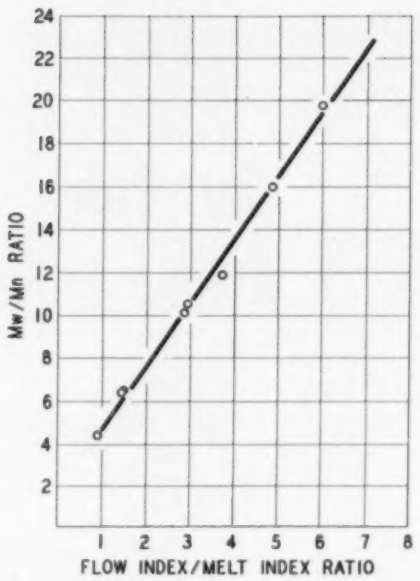

Figure 2. A correlation of molecular weight distribution with flow properties of linear polyethylenes

sponse to pressure becomes greater for polymers of broad distribution. Consequently, at those rates of shear commonly employed in commercial fabrication, polymers of a broad distribution will have a proportionally higher flow rate than resins with a narrower molecular weight distribution. This is illustrated in *Figure 1* where shear rate vs. shear stress is plotted for two polymers of the same melt index but exhibiting different molecular weight distributions. This curve is typical of the flow response that can be expected of polymers exhibiting different molecular weight distributions. The only difference when comparing other polymers may be in the degree of flow response which would depend on the difference in molecular weight distribution between the polymers under consideration. From an examination of this graph, it is apparent that flow data obtained at several pressures is much more informative than melt index in providing a relative indication of the processability of resins.

In the last several years many companies have done exhaustive flow studies with a gas operated high shear viscometer developed by Canadian Industries, Limited, (CIL). These studies have, for the most part, been concerned with characterizing resins by means of rheological data, such as critical shear rate, critical shear stress, average slope above and below the critical point, etc. Unfortunately, a complete flow curve would have to be obtained before such data could be determined. Although such a curve is invaluable from a fundamental standpoint, it doesn't lend itself readily to a rapid and simple method for quality control. Therefore, our work was focused on finding some method which would provide a rapid means for characterizing resins.

It was assumed that the flow of a resin at some selected pressure on the flow pressure curve could be correlated with actual performance. With this in mind, the flow in grams at 1800 psi through a standard CIL orifice at 190°C for a given time interval was selected for our initial studies. Subsequent work, however, indicated that for high viscosity polymers, this pressure was borderline as far as melt fracture was concerned. Consequently, the pressure was reduced to 1500 psi. The flow in grams in 10 minutes at this pressure was designated as the flow index. It soon became apparent in our studies that comparison of polymers on the basis of this index still left much to be desired.

From a consideration of the preceding discussion it appears that neither melt index nor flow index, when used alone, is sufficient to characterize polymers of varying molecular weight distributions. One method which may have suggested itself to the reader would be to compare polymers on the basis of both melt index and flow index. Unfortunately, some time would be required to familiarize oneself with melt index—flow index relationship in terms of polymer performance before such a system could be adopted. This time factor could be eliminated if the flow index of a resin could be related in terms of some value that is readily recognized and understood by the Industry, e.g., as melt index. Such a method has been developed. Briefly, it con-

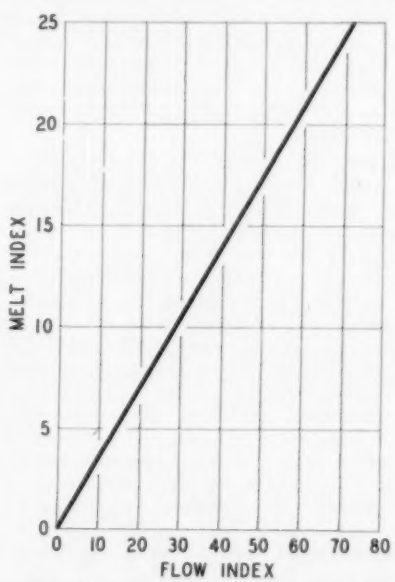

Figure 3. Correlation of melt index with flow index for polyethylenes of similar (Mw/Mn = 10) molecular weight distribution

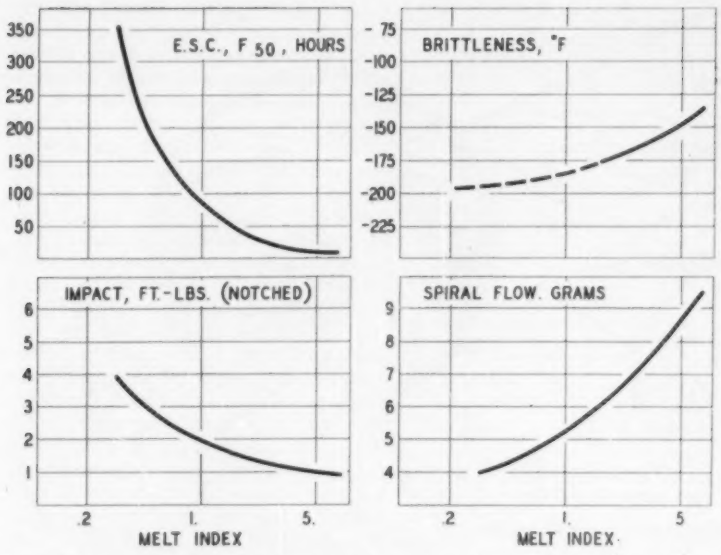

Figure 4. Comparison of polymer properties vs melt index; constant MIE/MI ratio

sists of determining the flow index of a resin and subsequently relating it to a standard reference melt index vs. flow index curve. The melt index on the standard curve corresponding to the flow index of the material in question is designated as its melt index equivalent.

The major obstacle to be resolved before such a system could be adopted is the selection of a standard reference curve. For obvious reasons, it was decided that this curve should not be based on the flow properties of any conventional resin per se, but rather, should be based on some fundamental property of the resin. Since the need for some other method to characterize polymers was due primarily to the differences in the molecular weight distribution between resins, it was decided that this parameter should be a determining factor in the selection of any standard curve.

A relative indication of molecular weight distribution may be obtained from knowledge of the molecular weights. Since polymer material is usually composed of large molecules covering a broad range of molecular weights, the molecular weight of these resins is always expressed as an average. The number-average molecular weight is the simplest average and is based largely on the number of molecules in the sample. The weight average molecular weight, on the other hand, depends on the total weight of the individual molecules of each size. In general, the closer that these values are to each other, the narrower the distribution. Consequently, the Mw/Mn ratio was selected as an arbitrary measure of molecular weight distribution.

From a purely theoretical viewpoint, a polymer exhibiting a Mw/Mn ratio of one would be ideally suited for a reference standard since all commercial resins would then have flow responses greater than that of the standard. This, however, was not practical since the melt index equivalent of all commercial polyethylenes would be so much greater than the actual melt index that this system would lose much of its intended usefulness. Since the majority of high density polyethylene resins had Mw/Mn ratios which ranged from 4 to 16, an arbitrary Mw/Mn ratio of 10 was selected for the standard reference curve.

Once the molecular weight distribution had been specified, it was necessary to obtain the necessary flow index and melt index data on the appropriate resins. This could be accomplished in several ways.

The most obvious choice would be to actually determine flow index values on resins whose molecular weight distribution corresponds to an Mw/Mn ratio of 10 for a whole series of resins of varying melt indices. This, however, would require the preparation of a great number of experimental resins because none were commercially available for the melt index range under consideration. Another means at our disposal would be to calculate the flow index for any melt index resin by a knowledge of the flow index/melt index ratio. This is based on the assumption that the flow index/melt index ratio should be a constant for any resin of the same molecular weight distribution regardless of melt index. This assumption is confirmed by an examination of *Figure 2* in which Mw/Mn ratio of resins possessing various melt indices is plotted vs. the flow index/melt index ratio.

Having established that the flow index/melt index ratio is a constant for resins of the same distribution, this ratio was determined for a resin whose molecular weight distribution corresponded to an Mw/Mn ratio of 10. The flow index was then calculated for resins of various melt index from this value. *Figure 3* illustrates this melt index to flow index relationship. As was mentioned earlier, the melt index on this curve which corresponds to the flow index of the resin is designated as its melt index equivalent. In the following, the uses of this new index will be explored.

Assume that we have determined the flow index of a resin and ascertained its melt index equivalent from the standard reference curve. The question in most everyone's mind is "what does this tell us regarding the polymer in question?". In the first place, a knowledge of the melt index equivalent/melt index ratio will give us some indication as to its relative molecular weight distribution. In general, a ratio of one would correspond to a polymer whose molecular weight distribution would be defined by an Mw/Mn ratio of 10. A ratio of less than one would necessitate that its Mw/Mn ratio would be less than 10, while a ratio of greater than one would mean it had a distribution corresponding to an Mw/Mn ratio of greater than 10. *Figure 2* indicates more precisely the molecular weight distribution of a resin.

Table 2. Comparison of Polymers on the Basis of Similar Melt Index Equivalent

	ASTM Method	Experimental Resin "E"	Experimental Resin "F"
Density	D1505-57T	.955	.955
M.I.	D1238-57T	.20	1.2
Flow Index, gms/10 min.	—	1.6	1.6
Melt Index Equivalent	—	.54	.54
Spiral Flow, gms.	—	3.9	3.9
Tensile Strength, psi	D638-58T	4500	4470
Elongation, %	D638-58T	29	27
Stiffness, psi	D747-58T	143,000	145,000
Impact, ft-lbs. (notched)	D256-56	7.2	5.8
ESC, F_{50}, hrs.	—	90	35
Brittleness Temperature, °F	D746-57T	—180°F	—180°F

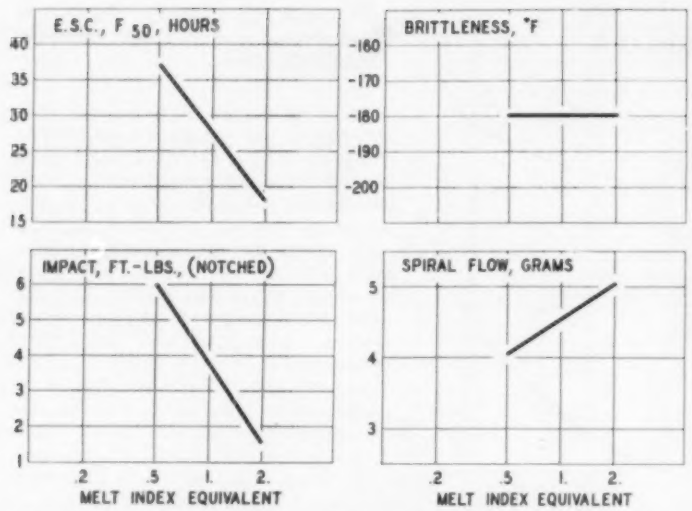

Figure 5. Comparison of polymer properties vs melt index equivalent; constant melt index

Besides defining the molecular weight distribution of a resin, a knowledge of the melt index and melt index equivalent can be useful in predicting the differences in properties between any resins of similar density. In order to simplify the characterization process, the polymers are grouped into one of three separate categories. The categories, which are listed below, are based largely on the similarity between melt index and melt index equivalent values of the resins under consideration.

1. Melt index equivalent/melt index ratio is identical for the two polymers being compared.
2. The two resins have similar melt indices.
3. The two resins have similar melt index equivalents.

Once the resins have been classified, the following generalizations regarding their comparative properties can be made:

1. When comparing resins which have the same melt index equivalent/melt index ratio, (same molecular weight distribution) the resin with the lower melt index will, in general, have better impact strength, better environmental stress cracking resistance, lower brittleness temperature, and poorer processability. This is illustrated in *Figure 4*.
2. When comparing resins of the same melt index, the resin with the lowest melt index equivalent (the narrowest molecular weight distribution) will generally exhibit better impact strength and environmental stress cracking resistance, improved brittleness temperature and lower processability, as measured by spiral flow. These data are illustrated in *Figure 5*. It should be noted that for low melt index resins, the improvement in brittleness temperature with decreasing melt index equivalent is not as apparent as with the higher melt index resins.
3. When comparing resins of similar melt index equivalent, the resin with the lower melt index will, in general, have better impact strength and environmental stress cracking resistance than higher melt index resins. Brittleness temperature, on the other hand, appears to improve with increasing melt index, while spiral flow is seemingly independent of melt index for polymers of similar melt index equivalents. These data, which are illustrated in *Figure 6*, gives some indication of the interrelationship that molecular weight and molecular weight distribution have on polymer performance.

Specific examples illustrating categories 2 and 3 of the above discussion are presented in *Tables 1 and 2*. In regard to resins which are not included in any of the above categories, there are several comments which may be made. In general, polymers which exhibit low melt indices coupled with a narrow molecular weight distribution will have better properties (with the exception of processability) than polymers exhibiting a broad molecular weight distribution (high MIE/MI ratio) with either a low or high melt index. It is difficult to generalize in the case where a resin with a low melt index and broad molecular weight distribution (high MIE/MI ratio) is compared to a resin exhibiting a high melt index and a narrow molecular weight distribution (low MIE/MI ratio) since such a comparison depends primarily on the order of magnitude of melt index and molecular weight distribution of the resins in question. In those instances or at times where more definitive information is required in regard to the properties of resin, a three dimensional graph relating the property under consideration with both melt index and molecular weight distribution would have to be constructed for a given resin density. Until such data can be developed, melt index equivalent, together with melt index should provide a suitable criterion for polymer performance.

Acknowledgments

The authors would like to express their appreciation to the Physics Branch of the Research Development Division of Phillips Petroleum Company for furnishing the molecular weight data used in this paper.

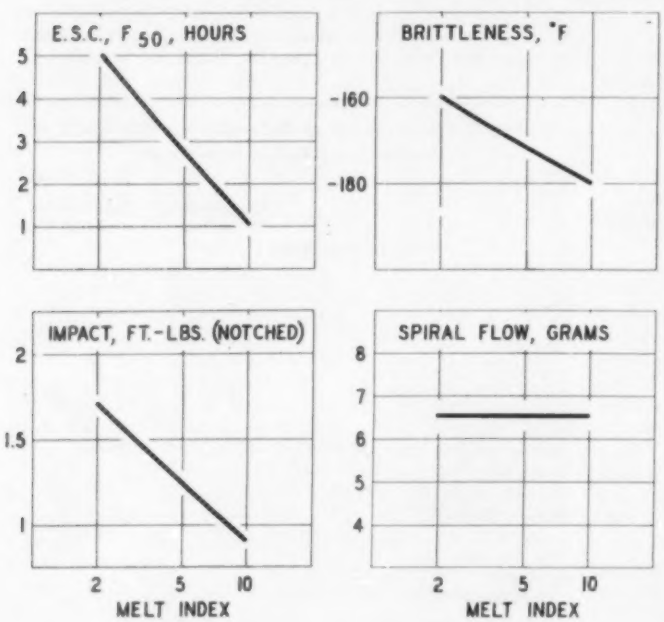

Figure 6. Comparison of polymer properties vs melt index; constant melt index equivalent

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STATUS REPORT:

Monsanto plastics for packaging & the food additives amendment

As part of Monsanto's continuing responsibility to customers and to package users, we present this up-to-the-minute status report of Monsanto plastics for food packaging and a brief definition of terms important to a general understanding of the Food Additives Amendment, which became effective March 6, 1960 ■ Monsanto's extensive research and development over the years have resulted in many plastic formulations from ingredients which are generally recognized as safe or which have prior sanction or which have no reasonable expectation of migration ■ By using the Monsanto plastics listed on the following page, you can be certain of packaging materials which comply with the Food Additives Amendment. We will keep you informed of additions.

MONSANTO DEVELOPER IN PLASTICS

The Status of Monsanto Plastics—September, 1960

PRODUCTS	BASIS FOR RECOMMENDED USE IN FOOD PACKAGING
LUSTREX® STYRENE PLASTIC	
General Purpose Molding Grades	
Hi-Flow 55 Hi-Flow 66 Hi-Flow 77	Generally recognized as safe and prior sanction.
Impact Molding and Extrusion Grades	
Hi-Test 42 Hi-Test 48 Hi-Test 88 Hi-Test 180	Extension granted by FDA until March 5, 1961 (Long term feeding studies highly favorable)
MONSANTO POLYETHYLENE (NATURAL)	
Injection and Blow Molding Grades: 51, 52, 60, 80, 705, 805, 935, 9752	Prior sanction for non-fatty foods.
Film Extrusion Grades: 30, 31, 32, 33, 34, 37, 38, 706, 10406, 13406, 18300, 19706, 23406, 25706, 26706	Extension granted by FDA until March 5, 1961. (FDA is expected to acknowledge the safety of Polyethylene in contact with fatty foods prior to this date.)
Extrusion Coating Grades: 406, 537, 73	
VUEPAK® F CELLULOSE ACETATE	Generally recognized as safe and prior sanction.
OPALON® RESINS	
300 330 FM 300 FM	Prior sanction.
Polyvinyl chloride acetate copolymers	
506 510	Prior sanction.

DEFINITIONS

of terms important in understanding the Food Additives Amendment.

Food Additives Amendment—1958 Amendment to the 1938 Federal Food, Drug and Cosmetic Act. It requires, for the first time, that any chemical compound in food, whether intentional or incidental, must be proved safe before the food is put into interstate commerce. The amendment became effective March 6, 1960.

Food Additives—All chemical compounds in food are *not*, however, in *legal* sense food additives. Compounds with prior sanction or which are generally recognized as safe are specifically excluded by the new statute from the category of food additives.

Prior Sanction—Before the 9/6/58 enactment of the Food Additives Amendment, the Food and Drug Administration and divisions of the United States Department of Agriculture had only limited authority to approve use of chemical compounds in foods. Favorable response to a request for approval normally meant an informal letter of no objection—now classified as a prior sanction—exempt under the new amendment.

Generally Recognized as Safe—The FDA interprets this to mean that it is the widely held opinion of acknowledged authorities that a given chemical compound is safe in human food. FDA has published in the Federal Register, lists of compounds which are considered generally recognized as safe.

No Reasonable Expectation of Migration—It is obvious that chemical compounds not in food cannot be food additives. But the definition of "zero" content requires scientific judgment. No reasonable expectation of migration (of pharmacological significance) realistically recognizes that infinitesimally small amounts of certain chemical compounds may be and generally are present in processed foods without hazard.

* * *

A special report on food packaging colorants has been prepared for package manufacturers using colorants in their packages. For this report, write to Monsanto Chemical Company, Plastics Division, Room 773, Springfield 2, Massachusetts.

Vernon L. Waldon
President, Plastene Corporation
A Subsidiary of American Thermos Products Co.

"With our coast-to-coast and Canadian operations, we look for molding equipment that is 'backed' to the limit. We bought H-P-Ms for all four of the plants because they are high producers and dependable. Then, too, H-P-M has superior engineering and service organizations to give us the kind of service backing we need."

V L Waldon

Display boxes for Timex Watches are produced in a 12 Cavity mold on this H-P-M 450-HV-20/28 (20/28 oz. capacity) machine. Weight of shot — 22½ oz. Projected area — 265 sq. in. Molded at Plastene Corp., Crawfordsville, Indiana.

10 New H-P-Ms in 2 Year Expansion Program

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To be "on the move" in the fast growing plastic industry, you'll appreciate the backing of a sales engineering and service force strategically located to keep your equipment operating at top production capacity. You get this with H-P-M for preventative maintenance, parts replacement or machine modification. For complete information on injection molding machines — 6 to 300 oz. — call your H-P-M sales engineer today. Buy the line that's "backed" the best to keep you "moving" at top production.

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HPM

H9

SOCIETY ACTION

Highlights of October 18 Council Meeting

Robert D. Forger, *SPE Staff*

Three major items on the agenda of the third meeting of the 1960 SPE Council were election of Society Officers for 1961, establishment of an SPE Technical Program Committee and action upon a proposed plan for Future Organization of the Society's Management. Results of the election have already been reported in the November issue on page 1254.

Technical Program Committee

An important milestone in the meetings area was Council approval of formation of an SPE Technical Program Committee with the initial assignment to plan the technical program for the 18th ANTEC, sponsored by the Pittsburgh Section in early 1962. The Committee is organized to include representation and participation of the Meetings Committee, PAGs, Editorial Advisory Board and the Program Chairmen of past and future ANTECs. The objective is to provide a committee representative of our entire membership and continuity from one ANTEC to another.

This new Committee is divided into two separate Boards, each of which is responsible for a specific phase of the programming operation. The Program Board plans, organizes and implements the technical program and is responsible for selection and invitation of both speakers and moderators. Review and rating of technical papers is assigned to the Papers Review Board with responsibility for final selection resting with the Program Board.

Chairman of the Committee will be appointed annually by the SPE President and will usually be a member of the Section sponsoring the next ANTEC. The Secretary, who assists the Committee in the initial solicitation and procurement of papers and is completely responsible for speaker and moderator contact after their acceptance by the Committee, will be an SPE staff member.

Organization of the Technical Program Committee was completed at a gathering of the Meeting Committee in Pittsburgh on November 9. First formal meeting was held in Washington on November 28 with Chairman George C. Kiessling of the Pittsburgh Section presiding.

New Society Management Plan

Developed by an Ad Hoc Committee and unanimously approved by Council, the new organization streamlines the Society's management by separating engineering and administrative functions. While both the plan and first reading of By-Law changes necessary to effect it were approved by Council, favorable Council action on second reading of the By-Law changes is required for final adoption.

Under the new organization all engineering activities are the responsibility of an Engineering Board chaired by the Vice-President, Engineering (formerly First Vice-President). The first 12-member Board will be appointed by the Vice-President, Engineering and will be representative of the various facets of the plastics industry.

Similarly, an Administrative Board, chaired by the Vice-President, Administration (formerly Second Vice-President), will direct activity of all administrative Committees. Council will retain all of its present powers as the governing body of the Society, but will delegate more of its powers to the Executive Committee. In this manner, only three Council meetings per year will be required, two of which will be held at ANTEC.

More complete details of the new organization will be published in the Society Action feature of the January 1961 issue of the SPE Journal.

SPE By-law Changes

In addition to approving first reading of revised By-Laws to implement the above plan, Council also gave its unanimous consent to first reading of new By-Laws which would permit two-day RETECs and audit of the Society's books by either a certified or registered public accountant.

Approval of second and final readings of changes originally proposed at the May meeting include:

1. A rebate of $1.00 to Sections for each Student Member affiliated with the Section.
2. Provision for removal of a Councilman who fails to attend one of three consecutive Council meetings.

Finances

Council approved the 1959-1960 Annual Financial Statement of the Society (to be published as part of the Annual Report in the February issue) as well as the statement for the first quarter of the 1961 fiscal year. Favorable action was also received by proposals to establish a pension plan for staff employees of the Society and to add a new SPE Journal advertising salesman to cover part of the Eastern Territory.

PAGs and Meetings

In this area, Council approved establishment of SPE's 16th Professional Activity Group "Coloring of Plastics" and received progress reports of activities of other PAGs. Of particular interest was a report on SPE cooperation with the American Society of Tool and Manufacturing Engineers in co-sponsoring of a "Plastics in Tooling" Seminar.

The complete meetings schedule, including eleven 1961 RETECs approved by Council, may be found in the "Technical Meetings Calendar" of this issue. In approving the North Texas Section petition for a RETEC, Council also authorized, on a trial basis, an engineering display to be held concurrently with the RETEC.

It was also agreed that all Section-sponsored meetings would be considered RETECs and that use of descriptive "Workshop" or "Seminar" subtitles to indicate the form of the RETEC would be encouraged.

New Career Brochure Announced

Among progress reports from virtually all of SPE's Standing and Ad Hoc Committees, was the Education Committee announcement that a new brochure "Plastics as an Engineering Career" would be available about the first of the year. Designed to influence careers in plastics science and engineering, the brochure is expected eventually to be widely distributed to guidance directors of the English speaking countries.

1960 Membership Contest Enters Final Month

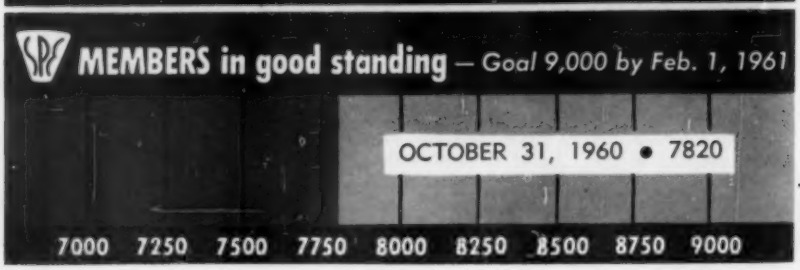
The Florida Section, retaining their early lead, still occupies first place in the 1960 SPE Membership Contest with a startling 28.4% increase in membership since April first. In second and third place respectively are the Monterrey and Rocky Mountain Sections, both of which have shown over 20% increases. As shown in the table below, Sections in 4th through 10th places all have an excellent opportunity to attain the 20% figure by the end of this year.

Results of the Inter-Regional Contest show that the same Sections which were in 1st place in their respective Regions as of June 30 have maintained this lead. However, there has been considerable changes in the other standings. A concerted campaign by any Section could result in winning the Regional banner.

So let's all get to work in the time that remains and "bring home the banner" for your Section. Remember, reports of new applications must be received in the Executive Office by December 30 in order to count in the 1960 Contest.

Leading Sections in SPE Inter-Regional Membership Contest as of October 31, 1960

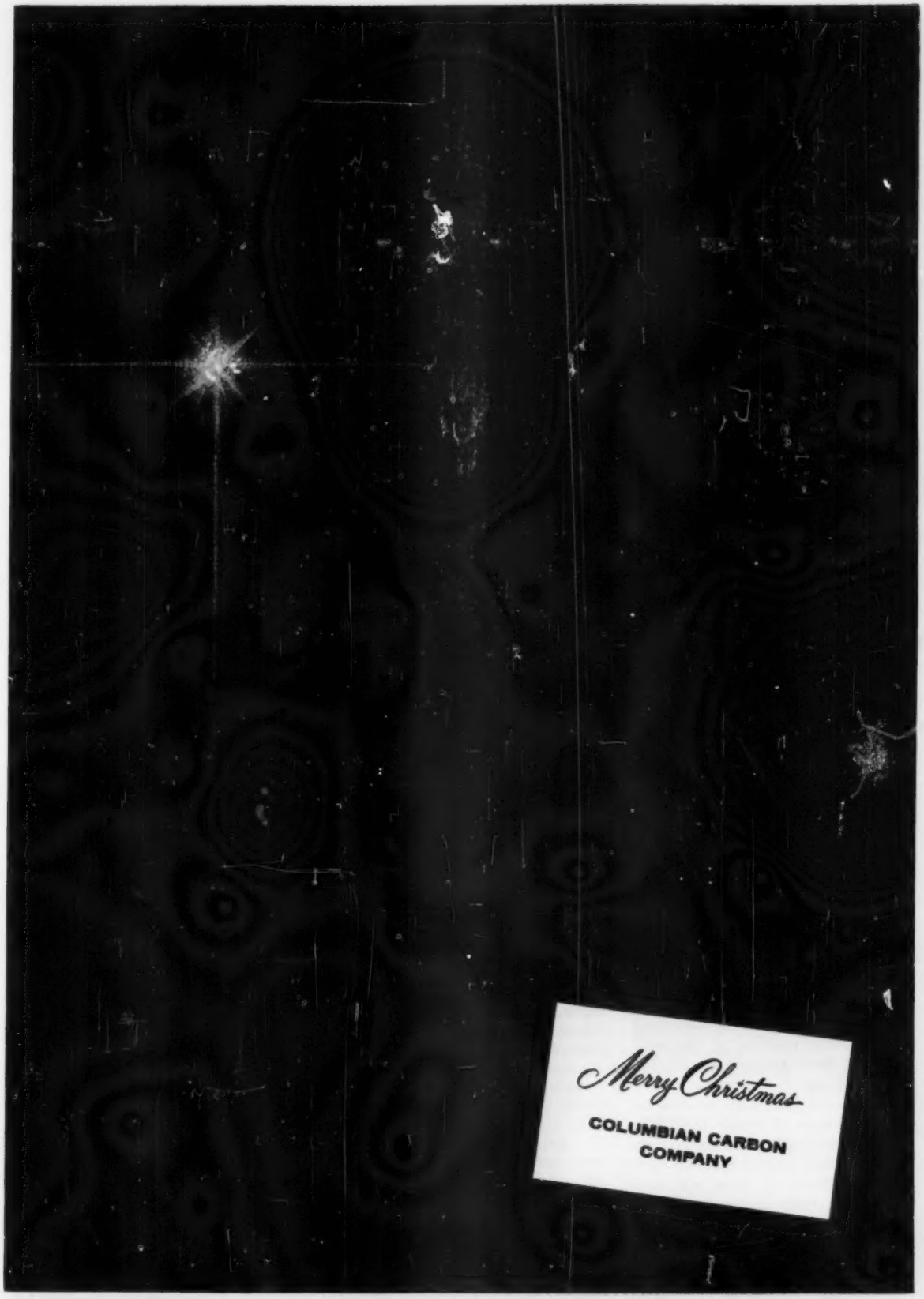
REGIONAL STANDING	SECTION	% INCREASE
	***REGION I*—NEW ENGLAND**	
1.	Southeastern New England	15.1
2.	Pioneer Valley	10.0
	***REGION II*—IROQUOIS**	
1.	Ontario	16.6
2.	Quebec	14.0
	***REGION III*—MID-ATLANTIC**	
1.	Baltimore-Washington	8.1
2.	New York	7.4
	***REGION IV*—EAST CENTRAL**	
1.	Cleveland	11.2
2.	Central Indiana	8.5
	***REGION V*—SOUTHWEST**	
1.	Florida	28.4
2.	Monterrey	24.2
	***REGION VI*—GREAT LAKES**	
1.	Toledo	16.5
2.	Upper Midwest	8.2
	***REGION VII*—WESTERN**	
1.	Rocky Mountain	21.2
2.	Pacific Northwest	13.3



1960 SPE Membership Contest Standings as of October 31, 1960

POSITION	SECTION	% INCREASE
1	Florida	28.4
2	Monterrey	24.2
3	Rocky Mountain	21.2
4	Ontario	16.6
5	Toledo	16.5
6	Southeastern New England	15.1
7	Quebec	14.0
8	Buffalo	13.6
9	North Texas	13.5
10	Pacific Northwest	13.3

Edited by
Thomas A. Bissell,
Executive Secretary


Merry Christmas
COLUMBIAN CARBON
COMPANY

NEW BOOKS

HIGH SPEED TESTING, Vol. 1

Proceedings of a Symposium held at Boston, Dec. 1958

Co-Chairmen: A. G. H. Dietz and Frederick R. Eirich, Interscience Publishers, Inc., 112 pp. $5.00.

Three of the eight chapters which deal mainly with the theory and practice of the behavior of thermoplastic polymers in tension are of particular interest to plastics engineers. Other chapters on package cushioning materials, textile yarns, rocket fuels and metals show that the problem of selecting the correct time scale for destructive tests is not limited to plastics.

A brief review of stress relaxation theory by Henry M. Morgan serves as useful background for the other two chapters respectively by Richard E. Ely and Stephen Strella. These cite pertinent examples to illustrate the large magnitude of the rate effect on tensile properties with some comment on the practical significance of the effect and also describe the state of the art up to 1958 in providing better machines for high speed testing.

This small book obviously cannot be a comprehensive data reference or a significant text on theory. For the engineer who uses tensile data without being familiar with the theoretical and practical problem of obtaining such, the three chapters on thermoplastics present a concise review which should help him to evaluate the significance of tensile tests. The considerable detail on design features of high speed tensile machines will have significance to those who contemplate a choice among the several commercial models of machines which are now available.

Edward G. Bobalek
Case Institute of Technology

PROGRESS IN PLASTICS, 1959

Edited by Phillip Morgan, The Macmillan Co, N. Y., 216 pages, $12.00.

The well known editor of *British Plastics* is presenting the papers of 15 contributors to the 1959 International Plastics Convention. For the first time, the reader will have the privilege of digesting these papers *in extenso* instead of the abridged form in which they were read at the convention.

The Authors represent 4 nations: Great Britain (10), United States (2), Holland (2) and Germany (1). Their papers cover Polypropylene, its properties and molding characteristics; epoxy resins and thermoplastics; copolymers; the progress of glass reinforced plastics in the Benelux countries, Germany, Great Britain and the United States.

Reading further, we find papers on expanded plastics, foams, smokes, snows with a special paper on expanded polystyrene; extrusion studies on thermoplastics and acrylics, including processes, methods and machinery.

There are 21 pages of excellent art plates on glazed paper and 95 text illustrations. We believe that this compendium will do a great deal for the advancement of plastics technology, as it covers the most recent uses and application of plastics, including radio waves, rockets and satellites.

Dr. Louis C. Barail
Barail Associates

THEORETICAL ELASTICITY AND PLASTICITY FOR ENGINEERS

By D. E. R. Godfrey, The Macmillan Co., N. Y., 311 pages, $9.00.

This manual, a theoretical introduction to elasticity and plasticity, is a comprehensive monograph which will be greatly appreciated by engineers and physicists. It is most suitable for research and reference purposes. The reader is helped by sample problems which give a more vivid aspect to the subjects. Answers are found in the appendix.

In the first chapters, stress and strain are studied, first individually, then in their relations. Then bending and torsion, two-dimensional elasticity and curvilinear coordinates are examined.

In the final chapters, the author describes loads, plates, plasticity under bending and torsional stresses, and mathematical methods.

This book is required reading for plastics engineers primarily interested in plasticity and elasticity. However, above-average training in mathematics is helpful in getting the best out of it. There are 154 diagrams and charts which make reading much easier.

Dr. Louis C. Barail
Barail Associates

POLYSTYRENE

W. C. Teach and G. C. Kiessling, Reinhold Publishing Co., N. Y., 176 pages, $5.00

"Polystyrene" is a brief (176 page) attempt to cover a relatively vast field. As such it is a difficult task and the book of necessity is written in a general fashion.

Following a short history and introduction, the context delves into the properties, basic chemistry, manufacturing and fabricating techniques associated with polystyrene. The latter segment of the book then is devoted to foam materials and specialty applications. The final chapter summarizes the future prospects of this large volume polymer and offers some interesting ideas.

Emphasis seems to lie heavily towards the foam and specialty applications such as latices, glass filled styrenes, coatings and low molecular weight uses. Inasmuch as the classical applications of polystyrene are widely known, the extensive treatment given on the foams and specialties is desirable. Innumerable other works cover the former quite adequately.

The Properties chapter could, however, stand more detail. The statements were far too general and lacked specific meaning. Much of what was said could readily apply to almost any thermoplastic thus not differentiating polystyrene on its own merits.

In contrast, the Basic Chemistry chapter was exceptionally sophisticated in its treatment. It was excellently done, following the theories introduced by Flory and other equally competent workers in the field. Unfortunately the depth of these theories is beyond introductory readers and therefore are not in harmony with the level of this text. A less exacting and more simplified treatment would bring the book into better balance.

It is felt future editions should modify these two chapters and offer greater detail in exp anations throughout the first 5 or 6 chapters. Nevertheless, "Polystyrene" in its present form is well worth reading for the general reader.

Alexander Jung
Rohm and Haas Co.

...why take risks on uneven catalyst activity?

Today, the most uniform economical urethane foams are being made with a new catalyst produced by M&T, the pioneer in the development of "one-shot" catalysts. This is CATALYST T-9,* specially manufactured to give a predictably high activity that is retained through normal storage and use. Because of its proved performance, M&T CATALYST T-9 has replaced stannous octoate in most "one-shot" systems, establishing new standards for fast and dependable reaction catalysis and foam uniformity.

Obtain more information about CATALYST T-9 by writing or calling Metal & Thermit Corporation, the only company that produces a complete line of tin catalysts.

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M&T "ONE-SHOT" CATALYSTS INCLUDE:

M&T CATALYST T-9 (stannous type)
Stannous Octoate and Stabilized Stannous Octoate
M&T CATALYST T-12 (organotin type)
M&T CATALYST T-8 (dibutyltin di-2-ethylhexoate)

OTHER M&T PRODUCTS FOR PLASTICS:

THERMOLITE® Organotin Vinyl Stabilizers
THERMOLITE® Ba-Cd and Auxiliary Stabilizers
THERMOGUARD® H- High Tinctorial Strength Antimony Flame Retarder
THERMOGUARD® L- Low Tinctorial Strength Antimony Flame Retarder

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METAL & THERMIT Corporation, Sn Sb P Si Ti Zr | inorganics and organometallics | Rahway N. J., Dept. J.

In Canada: M&T Products of Canada Ltd., Rexdale, Ontario

PAG Progress

Extrusion PAG Helps Shape ANTEC Program

Robert Bostwick,
Vice-Chairman,
Extrusion PAG,
(Union Carbide Plastics Co.)

The Extrusion PAG has been an active group for several years now. The scope, as formulated in January 1959, is still appropriate today—

(a) To raise the technological level of the extrusion field.
(b) To assist, coordinate, and stimulate activities of sectional subgroups.
(c) To solicit and review papers concerned with the extrusion field for presentation at ANTECs and NATECs.
(d) To help secure speakers on extrusion for the geographical sections.
(e) To further the aims of the SPE and other PAGs.

The emphasis in the 1959 program, under the able chairmanship of Mr. John H. Myers, Foster Grant Co., was on item (a). Recent years have seen an increased understanding of the theory of extrusion, with an increasing number of workers and papers in the area of extrusion fundamentals. How to deliver this information in concentrated and useful form to people in the extrusion business was the question the Executive Committee of the Extrusion PAG asked itself in the latter part of 1958. The answer came in the organization and execution of three Extrusion Workshops during 1959, under the direction of Mr. Robert D. Sackett, Waldron-Hartig, and with the cooperation of the sponsoring SPE Sections.

These two-day workshops were held in April at Lowell Technological Institute, Lowell Mass. with 75 registrants; in June at Newark College of Engineering, Newark, N. J. with 100 registrants and in October at Ohio State University, Columbus, Ohio with 125 registrants. The "faculty" consisted of authorities in the field—E. Veazey of Dow, B. H. Maddock of Union Carbide, F. Nissel of Prodex, E. C. Bernhardt and H. Kessler of duPont, M. Underwood of Monsanto and J. Badonsky of Waldron-Hartig. The curriculum covered such meaty subjects as heat transfer, extruder design, power requirements, flow theory, die design and take-off equipment. It is believed these workshops were a major service to the extrusion industry and enhanced the prestige of SPE.

Another service performed during 1959 was by the Bibliography Committee, headed by Mr. L. Street, Welding Engineers. As a result of the work of this committee, an extensive bibliography of extrusion literature was published in the July 1959 SPE Journal.

The emphasis in the 1960 program has been on item (c) of the scope—to solicit and review papers concerned with the extrusion field for presentation at ANTECs and RETECs. Officers for the year of 1960 are: Dr. Ernest C. Bernhardt of duPont as Chairman, Robert Bostwick of Union Carbide as Vice-Chairman, and A. Robert Gilden of Enjay as Secretary. The entire Executive Committee of the Extrusion PAG has participated in this activity, with the committee work under the guidance of Paul Richardson of duPont as Review Board Committee Chairman.

In order to assist the Speaker's Committee for the forthcoming ANTEC, the Extrusion PAG reviewed thoroughly all abstracts submitted in the field of extrusion and rated these, with recommendations for acceptance and rejection. In addition, the papers finally chosen have been carefully reviewed by the group as to form and content, with specific suggestions forwarded to the ANTEC Speaker's Committee.

A lively "Bull Session" has been planned for the Extrusion PAG portion of the 1961 ANTEC in Washington, D. C. This activity is under the direction of Frank R. Nissel of Prodex and John Badonsky of Waldron-Hartig and bids fair to be a stimulating attraction.

In accordance with the new PAG Constitution, the Executive Committee has elected officers for the coming year of 1961:—A. Robert Gilden as Chairman, Bruce H. Maddock as Vice-Chairman, and Bernard Zurkoff of Enjay as Secretary.

—— ■ ——

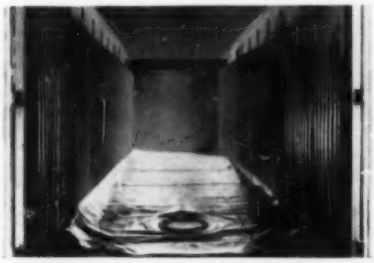
edited by
Frank W. Reynolds, *PAG Administrator*
(International Business Machines Corp.)

U.S.I. POLYETHYLENE NEWS

A series of advertisements for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

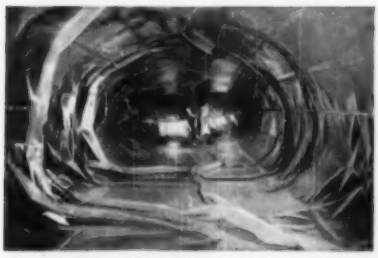
Disposable food-grade polyethylene liners are being used within large collapsible containers to haul edible liquids—milk, fruit juices, molasses and vegetable oils. The containers, recently introduced by a California company, can be carried on any van or flat-bed trailer, including refrigerated vans. They come in 22-, 30-, or 34-foot sizes, having capacities of 2,750, 4,000 and 4,600 gallons, respectively.

Following delivery, the disposable polyethylene liner is removed and the container rolled into a compact package, freeing the vehicle for a return trip with dry freight. To use the container again, it is unrolled on floor of truck and inflated. A sanitary poly liner is then easily spread within the container and also inflated—ready for another load.



Van-Tank is first unrolled on floor of trailer, inflated with low pressure air.

Sanitary plastic liner is quickly spread, with no contact with interior of liner.



Liner itself is then inflated, and Van-Tank is ready to receive its load.

Silver polish in a polyethylene tube stays creamy, won't dry out or cake up, and is more convenient to use. The exact amount needed can be dispensed right where it's wanted. And, when the squeeze is relaxed, excess is drawn back by the tube. New tube is printed in blue and red on white background, has a stand-on cap.

U. S. I. Introduces Two New PETROTHENE Resins For Injection Molding

Top Quality Polyethylene Resins Sell for New Low Price of 26¢ A Pound

U.S.I. has developed two new polyethylene resins tailored exclusively to the needs of injection molders producing toys, novelties and housewares. Called PETROTHENE 117 and PETROTHENE 213, they can be obtained from U.S.I. at 26¢ a pound—a record low price for top quality polyethylene resins.

New PETROTHENE resins are tailored exclusively for injection molded housewares, toys, and novelties.

PETROTHENE 117 (density 0.917 to 0.920, melt index 7.0 to 10.0) provides good appearance, extreme toughness and high gloss. Items molded from it can be expected to have low to medium stiffness.

PETROTHENE 213 (density 0.921 to 0.925, melt index 7.0 to 10.0) produces moldings of excellent appearance, good toughness and *very* high gloss. End products obtained are characterized by medium to high stiffness.

Processing Properties

PETROTHENE 117 and 213 are high-flow polyethylenes, so permit short injection molding cycles. Thus, economical production rates are possible. Molders of colored items will appreciate the ease of pigmentation offered by both new resins. They combine readily with most pigments by either dry blending or homogenization.

Optimum molding conditions will vary with equipment used and end-use requirements; these should be determined in each application. Technical assistance in determining proper conditions for specific applications is available on request from U.S.I. Technical Service Engineers. Or, for additional technical data on PETROTHENE 117 or 213 write Technical Literature Department, U.S.I., 99 Park Avenue, New York 16, N. Y.

Booklet Details Uses For Powdered Polyethylene

U.S.I. has published an 8-page booklet which explains in detail how U.S.I.'s finely divided or powdered polyethylene, introduced under the trade name "MICROTHENE", is used. Applications covered—many of which are not feasible with conventional polyethylene—include metal, textile, and glass; large moldings; and miscellaneous uses such as rubber additive, wax additive, and anti-tack agent. Data are also given on the sizes and grades of MICROTHENE polyethylene resins available. Copies may be obtained by writing to Technical Literature Department, U.S. Industrial Chemicals Co., 99 Park Avenue, New York 16, N. Y.

IF YOU WOULD LIKE further information on any developments reported in U.S.I. Polyethylene News, U.S.I. will be glad to send you the names of the manufacturers. U.S.I. also invites you to send information on your new developments for possible inclusion in the News.

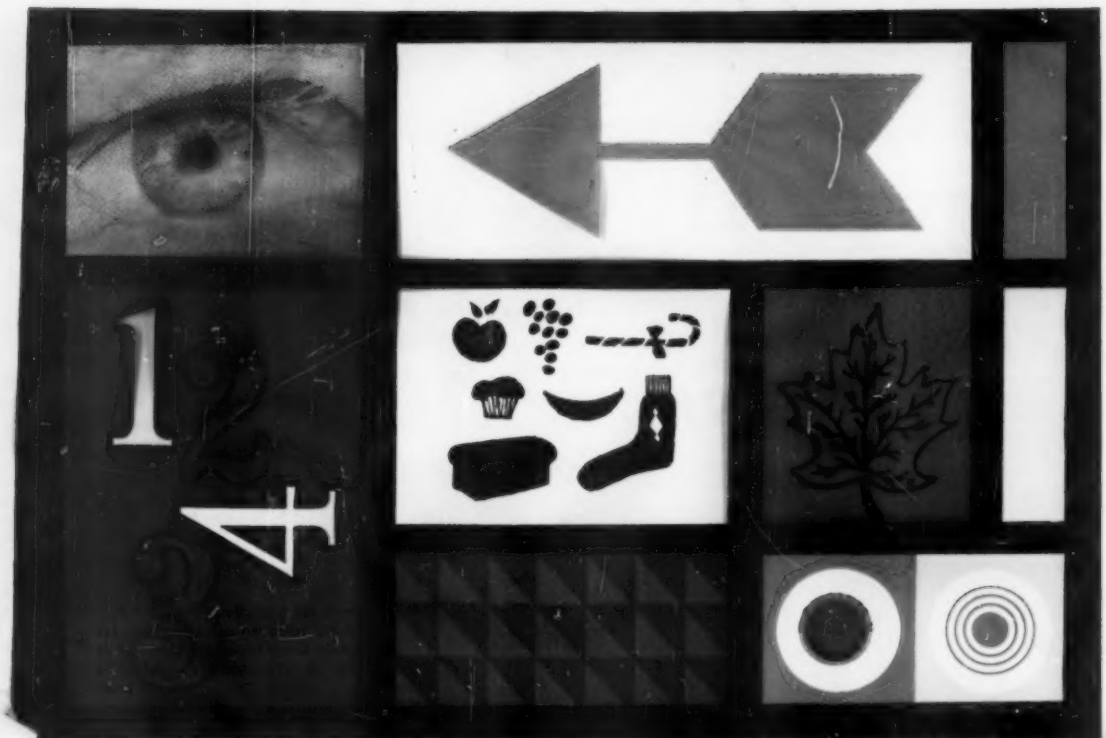
Address the Editor,
U.S.I Polyethylene News, U.S. Industrial Chemicals Co.,
99 Park Avenue, New York 16, New York.

Flower Pots Made from Coconut Husk Fibers with Aid of Polyethylene

In Puerto Rico, polyethylene film is being used as a mold liner in the production of plant pots from "Coir" fibers—the commercial name for the product obtained by defibering the husk of the coconut. These fibers—which are heavily lignified—yield potash and phosphoric acid on decomposition, so offer considerable value as fertilizer. Urea formaldehyde serves as a binder.

The developer of this process reports it has been in successful use for two years, credits polyethylene film with making it possible. Illustration shows how he lines mold cavity and punch with polyethylene.

Punch, mold cavity, and finished plant pot made of coconut fiber with help of polyethylene film.



Colorful Polyethylene

. . . offers your customers powerful sales advantages

When you supply your customers with polyethylene film, you provide them a packaging material that offers three important sales advantages. First, the film's toughness provides superior protection for packaged goods. Second, its clarity, high gloss and soft, natural flexibility add a look of quality and a clear unobstructed view of the product. Third, the film can easily be printed with colorful designs, sales messages and product information . . . producing brilliant showcases that draw attention to your customers' products.

Polyethylene film can be printed at high speeds, with sharp registration and good ink adhesion. Packages can be formed on automatic machinery and sealed by heat.

U.S.I. produces a number of PETROTHENE® polyethylene resins ideally suited for producing clear or printed packaging film. These resins offer excellent drawdown properties and a superior combination of toughness and clarity in finished film.

A helpful new U.S.I. booklet, "Printing On Polyethylene", is available upon request. It contains information on film treatment, printing techniques, inks, and field test procedures. For your copy, or for information about PETROTHENE resins, contact your nearest U.S.I. sales office or write to the address below.

U.S.I. is helping to expand your polyethylene film market with ads, similar to this one, addressed to the package-using industries. These ads are designed to pre-sell your potential customers on the sales appeal and other advantages of polyethylene film packaging.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N. Y.
Branches in principal cities

SPE Education Committee Surveys Polymer Courses

A search of university bulletins for courses offering instruction in polymeric materials as part of the course

C. C. Winding, *Chairman, SPE Education Committee*
(Director, School of Chemical and Metallurgical Engineering, Cornell University)

The Education Committee of the Society of Plastics Engineers has endeavored to determine the amount of instruction in polymeric materials offered at the university level. A survey of 106 universities was completed in August 1960 in which the arts and sciences, engineering, and graduate bulletins of these schools were searched for descriptions of courses dealing with instruction in polymeric materials. Three previous surveys were made in 1951, 1953, and 1956. In these surveys, questionnaires were sent to a selected list of universities asking for information about polymer courses. The questionnaire method had two serious faults: some schools did not reply and the accuracy of the information obtained depended on the wording of the questionnaire, as well as the care with which it was filled out. A summary of the previous surveys was published in the August 1957 SPE Journal.

The committee felt that the questionnaire method was supplying incomplete information and for that reason undertook the task of searching the course descriptions in over 200 bulletins for statements indicating that instruction in polymeric materials was offered. Approximately two-thirds of the bulletins used were for the school year 1959-60; the rest covered 1960-61. In addition to complete polymer courses, the bulletins were examined for information indicating the amount of time devoted to polymeric materials in courses dealing primarily with other subjects. Elementary organic chemistry courses were excluded since it was assumed they would all include a brief discussion of polymers and polymerization processes.

All the data were converted to a semester credit hour basis in which a credit is equivalent to approximately 15 hours of lectures or recitations, or 30-45 hours of laboratory work. A considerable amount of estimation was necessary in evaluating those courses in which only a minor part of the subject matter deals with polymers and converting the data to the common basis. However, in most cases the amount of instruction on polymers in non-polymer courses such as materials, advanced chemistry, chemical technology, etc., amounted to only a fraction of a credit, so estimation errors have a minor effect on total figures.

Courses completely devoted to polymers dealt with chemistry of polymers, plastics, rubbers, synthetic fibers, protective coatings, adhesives, rheology, fabrication methods, and both mold and product design. It must be remembered that all courses included are at the university level and part of degree programs though usually elective rather than required. This survey does not include any courses offered in two-year institutes, nor does it include any special non-credit "refresher" or "adult education" courses offered by various four-year schools. Where night school offerings are part of degree programs, they are included.

The table on pages 1352-3 summarizes the results obtained from all four surveys.

This table indicates several levels of the amount of instruction offered. More than 20 credits normally indicates an option, degree, or major in polymeric materials for either graduate or undergraduate students, usually in a special field such as textiles, rubbers, or protective coatings. Several schools in the 10 to 20 credit classification offer majors or minors at the graduate level and this amount of work plus courses in engineering, chemistry, and physics are enough to permit a student to specialize in a branch of the broad field of polymers.

In the last decade there has been a definite trend away from any specialization in engineering education at the undergraduate level. Greater emphasis has been placed on fundamentals and additional work in the humanistic-social areas, usually at the expense of applied or specialized instruction. For these reasons there also is little or no time for technical electives in a four-year engineering curriculum, so most of the polymer courses are for graduate students.

Percentagewise, no trends are obvious. In over a third of the schools, polymers are mentioned only briefly in various courses on materials and this situation has changed little in the last ten years. Of the 19 schools offering less than one credit in 1956, only two have changed appreciably: one to three credits and the other to five. The number of schools offering more than 20 credits increased from three to eight during the past four years. Three of the eight were not included in previous surveys. The other two additional schools in this category showed a marked increase in the number of credit hours offered. Of the eight, one university specializes in rubbers and two in textiles and fibers.

Of the total number of credits in courses devoted completely to polymers, slightly over 40 per cent is given by chemistry departments, 33 per cent in chemical engineering, and 13 per cent in special textile and fiber departments. This leaves roughly one-eighth in all the other university divisions combined. This apparent emphasis on polymer chemistry and polymer preparation is certainly not unexpected. It showed up in all the previous surveys and has been well known to most people working in this field. It

SURVEY OF UNIVERSITY INSTRUCTION IN POLYMERIC MATERIALS

School	Polymer Tech.		Protect. Coatings		Polymer Lab. Courses		Materials	Textiles and Fibers		Plywoods and Laminates		Rheology	
	Polymer Courses	Other Courses	Polymer Courses	Other Courses	Polymer Courses	Other Courses	Other Courses	Polymer Courses	Other Courses	Polymer Courses	Other Courses	Polymer Courses	Other Courses
1. University of Akron	4				14		1/2						
2. University of Alabama							3						
3. University of Arkansas		2 1/2					1						
4. Bucknell University													
5. California Inst. of Tech.							3/4						
6. Univ. of California—Berkeley							1						
7. Carnegie Inst. of Tech.							1/4						
8. Case Inst. of Tech.	6		4										
9. University of Cincinnati	5 1/2												
10. Clarkson College of Tech.		1/4					1 1/2						
11. Clemson College								27					
12. Colorado State University							1/4			1			
13. University of Colorado	6						1/4						
14. Columbia University	6	1/2					1/4						
15. Cooper Union							1/4						
16. Cornell University	5	3/4			2		2 3/4						
17. Dartmouth University													
18. University of Dayton		1/4					1/2						
19. University of Delaware		1/4			2								
20. University of Denver							1/4						
21. University of Detroit		1/4					1/4						
22. Drexel Inst. of Tech.		1/4					1/4	4 2/3					
23. Penn College													
24. University of Florida	3		9				1/4						
25. Georgia Inst. of Tech.	2							4	1 1/2				
26. Harvard University							2						
27. University of Houston				1									
28. University of Idaho		1/2					3/4						
29. Illinois Inst. of Tech.	3	1/2	8				1/2						
30. University of Illinois										4			
31. Iowa State University	2 2/3						1 1/4	7 1/3					
32. State University of Iowa							1/2						
33. John Hopkins University	3											3	
34. Kansas State University	3						1/4						
35. University of Kansas	2	1/2					1/4						
36. University of Kentucky													
37. Lafayette College		1					1/4						
38. Lamar State College of Tech.							1/4						
39. Lehigh University							1/2						
40. Louisiana Polytechnic Inst.							3/4						
41. Louisiana State University							1/4						
42. University of Louisville	1		2	1/4									
43. Lowell Tech. Inst. of Mass.	25				6		1/4	19				2	
44. University of Maine	3												
45. University of Maryland	2			1/2	1								
46. Massachusetts Inst. of Tech.	18	1/4			1				1/2	3			
47. University of Massachusetts							1						
48. Mich. College of Mining and Tech.			5 1/3				1/4						
49. Mich. State University	4 2/3				2		1/4			2			
50. University of Michigan	18						1/4			4			
51. University of Minnestota	5 1/3	1/4					1/4				1/4		1
52. Mississippi State University	2				1		1/2						
53. Missouri School of Mines and Met.				1/2			1/4						
54. University of Missouri							1/2						
55. Montana State College							1/4						
56. University of Nebraska							1/4						
57. City College of New York	4						1/4						
58. New York University	6	3/4	12										
59. Newark College of Eng.	3						1/2						
60. North Carolina State College	6							18		3			
61. University of North Dakota													
62. Northeastern University		1/4					1/2						
63. Northwestern University	2						1/4						
64. University of Notre Dame		1					1/4						
65. Ohio State University		1/2											
66. Oklahoma State University		1/4			1		1/4	3					
67. University of Oklahoma							1/4						
68. Oregon State College	2							2		4			
69. Pennsylvania State University										3			
70. University of Pennsylvania		1/4											
71. Polytechnic Inst. of Brooklyn	10	1/2	4	2	6		1/2						
72. Pratt Institute							1/2						
73. Princeton University	11				1		1/4					3	
74. Purdue University	3						1/4			3			
75. Rensselaer Polytechnic Inst.					1							3	
76. University of Rhode Island								3					
77. Rice Institute													1
78. University of Rochester	2						1/4					2	
79. Rose Polytechnic Inst.													
80. Rutgers University				1/2			1/2				1/4		
81. University of South Carolina							2						
82. South Dakota School of Mines & Tech.	2	1					1/4						
83. Southwestern Louisiana Inst.						1/4	3/4						
84. Univ. of Southern California	9				2		1/2						
85. Stanford University							1/4			2 1/2			
86. Stevens Inst. of Tech.							1/2				3		
87. Syracuse University							1/4	5 1/3	3/4				
88. University of Tennessee							3/4						
89. A. and M. College of Texas		1/2					1/4	3	3/4				
90. Texas Technological College							1 1/4						
91. University of Texas							1/4						
92. Tufts University		1											
93. Tulane University							1/2						
94. University of Tulsa							1/4						
95. University of Utah							1/4						
96. Vanderbilt University		3					1/4						
97. Villanova University	6						1/4						
98. Virginia Polytechnic Inst.	4 2/3				2		1/2						
99. University of Virginia							1/2						
100. Washington University	6						1/2						
101. Wayne State University	10		4	1/4	4		1/4	2					
102. West Virginia University													
103. University of Wisconsin	8						1/4						
104. Worcester Polytechnic Inst.		1/2					1/4						
105. University of Wyoming										3			
106. Yale University													

also would be expected on the basis that over a third of the dollar value of chemicals ends up in polymers.

All but six schools indicate that some instruction in polymers is given. In many cases the amount of time alloted is certainly below what would normally be considered minimal, but it is probably true that more and more courses are being revised to recognize that plastics, rubbers, fibers, etc., should be a part of the general subject of materials.

There are very few laboratory courses involving plastics or rubbers. Where the emphasis is on textiles and fibers or protective coatings, there is likely to be more laboratory work. This is probably a reflection of the high cost of plastics and rubber laboratories. Even without allowances for the cost of floor space, such laboratories involve investment of up to $100,000. This is too high a cost for a specialized laboratory for a relatively few students as far as most universities are concerned. Those that have been installed usually involve special circumstances and were originally equipped for research rather than instruction.

SURVEY OF UNIVERSITY INSTRUCTION IN POLYMERIC MATERIALS

School	Total Credits in Polymer Courses	Total Credits in Other Courses	Credits in Chem. Eng. Departments: Polymer Courses	Credits in Chem. Eng. Departments: Other Courses	Credits in Chemistry Departments: Polymer Courses	Credits in Chemistry Departments: Other Courses	Credits in Other Departments: Polymer Courses	Credits in Other Departments: Other Courses	Chem. of Polymers: Polymer Courses	Chem. of Polymers: Other Courses
1. University of Akron	30	1/2			30			1/2	12	
2. University of Alabama	3	2		1/2	2		1	1 1/2	3	
3. University of Arkansas	0	2 1/2		2 1/2						
4. Bucknell University	0	0								
5. California Inst. of Tech.	0	3/4						3/4		
6. Univ. of California—Berkeley	0	1						1		
7. Carnegie Inst. of Tech.	3	1/4			3			1/4	3	
8. Case Inst. of Tech.	19	0	10		9				9	
9. University of Cincinnati	5 1/2	0	5 1/2							
10. Clarkson College of Tech.	0	1 3/4		1/4				1 1/2		
11. Clemson College	30	0			3		27		3	
12. Colorado State University	3 2/3	1/4			2 2/3		1	1/4	2 2/3	
13. University of Colorado	9	1/4	3		3		3	1/4	3	
14. Columbia University	6	3/4	6	1/2				1/4		
15. Cooper Union	0	1/4						1/4		
16. Cornell University	11	3 1/2	7		4			3 1/2	4	
17. Dartmouth University	0	0								
18. University of Dayton	0	3/4						3/4		
19. University of Delaware	12	1/2		1/4	12	1/4			10	1/4
20. University of Denver	0	1/4						1/4		
21. University of Detroit	0	1/2		1/2						
22. Drexel Inst. of Tech.	4 2/3	1			4 2/3	1/2		1/2		1/2
23. Fenn College	3 1/3	0			3 1/3				3 1/3	
24. University of Florida	15	1/4	12		3			1/4	3	
25. Georgia Inst. of Tech.	10	1 1/2	2		4		4	1 1/2	4	
26. Harvard University	3	2			3			2	3	
27. University of Houston	0	1		1						
28. University of Idaho	4	1 1/4		1/4	4			1	4	
29. Illinois Inst. of Tech.	13	1	11	1/2	2			1/2	2	
30. University of Illinois	8	0			4		4		4	
31. Iowa State University	12	1 1/4	2 2/3	1/4	9 1/3			1	2	
32. State University of Iowa	3	1 1/2		1/4	3	1		1/4	3	1
33. John Hopkins University	6	0	6							
34. Kansas State University	3	1/4	3					1/4		
35. University of Kansas	2	1			2	1/4		3/4		1/4
36. University of Kentucky	0	0								
37. Lafayette College	0	1 1/4		1 1/4						
38. Lamar State College of Tech.	0	1/4		1/4						
39. Lehigh University	0	1				1/2		1/2		1/2
40. Louisiana Polytechnic Inst.	3	3/4		3/4	3				3	
41. Louisiana State University	0	1/4		1/4						
42. University of Louisville	7	1/4	4	1/4	3				3	
43. Lowell Tech. Inst. of Mass.	70	2 1/4			30	2	40	1/4	18	2
44. University of Maine	3	1	3			1				1
45. University of Maryland	9	1/2	3	1/2	6				6	
46. Massachusetts Inst. of Tech.	22	3/4	9				13	3/4		
47. University of Massachusetts	3	1			3			1	3	
48. Mich. College of Mining and Tech.	5 1/3	1 1/4				1	5 1/3	1/4		1
49. Mich. State University	15 1/3	1/4	2		8 2/3		4 2/3	1/4	6 2/3	
50. University of Michigan	24	1/4	16		2		6	1/4	2	
51. University of Minnesota	7 1/3	2			2	1/4	5 1/3	1 3/4	2	1/4
52. Mississippi State University	3	1/2	3	1/4				1/4		
53. Missouri School of Mines and Met.	9	3/4		1/2	9			1/4	9	
54. University of Missouri	2	1/2		1/4	2			1/4	2	
55. Montana State College	0	1/4						1/4		
56. University of Nebraska	0	1/4						1/4		
57. City College of New York	4	1/4	4	1/4						
58. New York University	18	3/4	18	3/4						
59. Newark College of Eng.	3	1/2	3	1/4				1/4		
60. North Carolina State College	27	0	6				21			
61. University of North Dakota	0	0								
62. Northeastern University	0	1 1/2		1/2		3/4		1/4		3/4
63. Northwestern University	2	1/4	2					1/4		
64. University of Notre Dame	0	1 1/4		1 1/4						
65. Ohio State University	2	1		1/2	2	1/2			2	1/2
66. Oklahoma State University	7	1/2		1/2	4		3		3	
67. University of Oklahoma	0	1/4						1/4		
68. Oregon State College	10	0	2		2		6		2	
69. Pennsylvania State University	9	0			6		3		6	
70. University of Pennsylvania	4	1/4		1/4	4				4	
71. Polytechnic Inst. of Brooklyn	36	3 1/2	12	2 1/2	22	1/2	2	1/2	16	1/2
72. Pratt Institute	0	1/2		1/2						
73. Princeton University	18	1	3		3	3/4	12	1/4	3	3/4
74. Purdue University	6	1/4	3				3	1/4		
75. Rensselaer Polytechnic Inst.	10	0			7		3		6	
76. University of Rhode Island	3	1			3	1				1
77. Rice Institute	0	1						1		
78. University of Rochester	4	1/4	4	1/4						
79. Rose Polytechnic Inst.	0	0								
80. Rutgers University	6	1 1/4			6			1 1/4	6	
81. University of South Carolina	3	2			3			2	3	
82. South Dakota School of Mines & Tech.	2	1 1/4	2	1 1/4						
83. Southwestern Louisiana Inst.	0	1 1/4		1/2		1/2		1/4		1/4
84. Univ. of Southern California	13	1/2	11	1/2	4				4	
85. Stanford University	0	1/4						1/4		
86. Stevens Inst. of Tech.	10	1/4		1/4	7 1/2		2 1/2		7 1/2	
87. Syracuse University	0	3 3/4		1/2				3 1/4		1/4
88. University of Tennessee	7 1/3	1 1/4			7 1/3	1/4		1	2	1/4
89. A. and M. College of Texas	0	1 1/4		3/4				1/2		
90. Texas Technological College	3	1		1/4			3	3/4		
91. University of Texas	0	1 1/4		1/2				3/4		
92. Tufts University	0	1	1					1/4		
93. Tulane University	0	0								
94. University of Tulsa	0	3/4		1/2		1/4				1/4
95. University of Utah	2	1/4		1/4	2				2	
96. Vanderbilt University	0	3 1/4	3					1/4		
97. Villanova University	9	1/4	6	1/4	3				3	
98. Virginia Polytechnic Inst.	16 2/3	1/2	4 2/3	1/4	10			1/4	12	
99. University of Virginia	0	1/2		1/4				1/4		
100. Washington University	9	1/2	6	1/4	3			1/4	3	
101. Wayne State University	24	1 3/4	10	1/2	8	1 1/4	6		4	1 1/4
102. West Virginia University	3	0			3				3	
103. University of Wisconsin	14	1/4	5	1/4	6		3		6	
104. Worcester Polytechnic Inst.	3	3/4		1/4	3			1/2	3	
105. University of Wyoming	2	0			2				2	
106. Yale University	6	1			3	1	3		3	1

It should be remembered that the amount of instruction in course work is not the only criterion of interest in polymers in universities. Many schools have extensive research programs on polymers. Seminars and special lectures also deal with polymers. This type of activity is dependent on staff personnel and is quite variable depending on changes in the staff. There appears to be a slow but definite increase in the number of faculty members who have polymer training and interests.

The large table shows a break-down in semester credit hours of the amount of work offered in courses dealing with polymers for all of the 106 universities surveyed. There were 112 schools on the original mailing list but bulletins from six were not received. The basic list of schools included the 98 that have accredited chemical engineering curricula, plus 14 that the SPE Education Committee added because there was some reason to believe they offered work in this field.

Figures in Italics in the table indicate an estimation of the amount of time devoted to polymers in courses primarily covering other or broader subjects. Laboratory courses involving protective coatings, textiles, and fibers, and ply-

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woods are included under those headings and not under the title Polymer Laboratory Courses. Thus, this heading is restricted to laboratory courses on plastics and/or rubbers.

The eight schools offering more than 20 credits in polymeric materials are:

Institution	Credits	Remarks
University of Akron	30	Predominately Rubbers
Clemson College	30	27 in Textiles and Fibers
Lowell Technology Institute	72¼	Degree in Plastics
Massachusetts Inst. Technology	22	
University of Michigan	24¼	
North Carolina State	27	18 in Textiles and Fibers
Polytech. Inst. Brooklyn	39½	Plastics Option in Chem. Eng.
Wayne State University	24	

The degree program at Lowell has been described in the SPE Journal (page 36, July 1958). Akron's rubber program and Clemson's work on textile materials are special cases. North Carolina also shows 18 out of 27 credits in the textile field but their work in other polymer fields has been expanding. Ten of M.I.T's. 22 credits are given in the Building Engineering and Construction Department. Polytechnical Institute of Brooklyn has had a Plastics Option in their chemical engineering curriculum for many years. This option has been accredited by the American Institute of Chemical Engineeers and ECPD.

Clemson, Lowell, and Wayne State were not included in any of the previous surveys, so that increasing the survey from 65 schools in 1956 to 106 in 1960 added three universities in the over 20 credit classification. Akron, Michigan, and Brooklyn Poly were in this classification in 1956. M.I.T. and North Carolina increased their offerings since the last survey.

It should be emphasized that total number of credits is not the only criterion for measuring good polymer programs. Research has been mentioned previously but other factors are involved. Princeton has a master's degree program in plastics for all types of engineers. Cornell has special programs for both graduate and undergraduate chemical engineers. Both of these schools fall in the 10 to 20 credit classification and there are undoubtedly other such programs in the 16 schools in the 10 to 20 credit level.

Summary of Surveys of Course Offerings in Polymeric Materials

	Number				Per Cent			
	'51	'53	'56	'60	'51	'53	'56	'60
Number Universities Surveyed	37	55	65	106	100	100	100	100
Schools offering more than 20 credits	4	4	3	8	11	7	5	8
Schools offering 10 to 20 credits	5	5	8	16	14	9	12	15
Schools offering 5 to 10 credits	10	9	13	20	27	16	20	19
Schools offering 1 to 5 credits	12	27	21	41	32	49	32	39
Schools offering less than one credit	6	10	19	21	16	18	29	20
Schools offering no courses completely devoted to polymers				34				32

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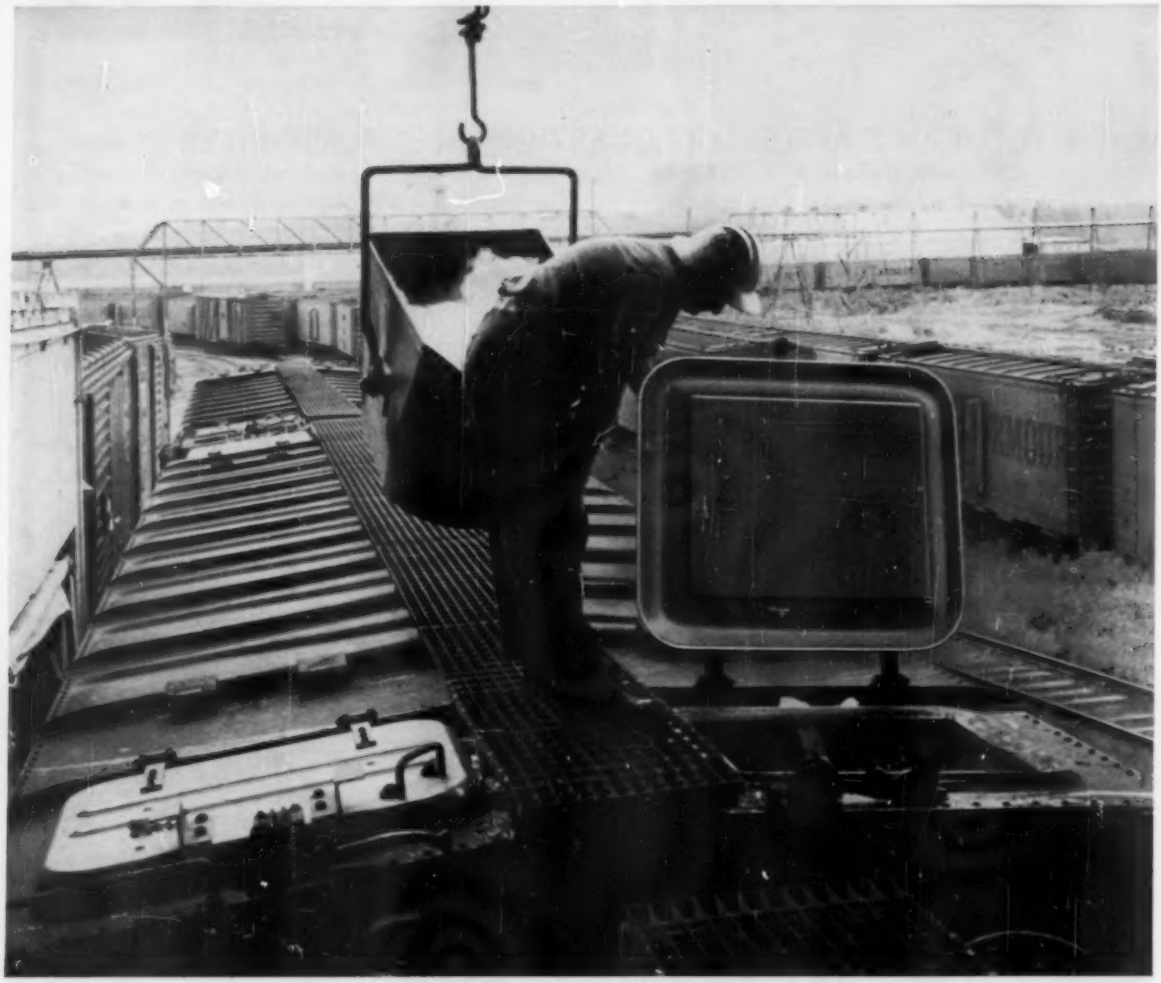

BRINE LOSES ITS BITE

When "reefer" hatch covers are preform moldings

Refrigerator car hatch covers take a beating from weather, hard use, and corrosive brine. Preform molded polyester hatch covers prove they can take it, and save money for the user, as well!

The Plastics Division of General American Transportation Corporation preform molds the durable hatch covers shown above for Standard Railway Equipment Manufacturing Company. The results are economical covers with excellent resistance to weathering and to the attack of salt; they won't warp or lose their strength and they last the life of the car with little or no maintenance.

Reinforced polyester moldings are low in cost, too. Nearly any configuration can be molded, greatly reducing the number of costly production operations normally required by other materials.

Preform moldings offer advantages in cost, in production ease, in long life under difficult service conditions; and the types of products for which they can be used are virtually unlimited. The Dow Chemical Company supplies the basic monomers for polyester resins for premix, preform and mat moldings—Dow styrene and Dow vinyltoluene.

For information on these Dow monomers, write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1967EX12.

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This month's column has been made possible through the contributions of these abstracters:
Alfred L. Alk (Poliplasti)
Hans Mayer (Industrie de Plastiques Modernes)
R. George Hochschild (Der Plastverarbeiter, Kunststoffe and Plaste und Kautschuk)
Alexander Baczewski (L'Officiel des Matières Plastiques)

PLASTICS AROUND THE WORLD

Italy

POLIPLASTI

MAY-JUNE 1960

New Transparent Thermoplastic Copolymers Derived from a Fermentation Acid—pp 3-7

A previous article introduced a binary copolymer of styrene and dimethyl itaconate and a ternary including acrylonitrile. This paper details the determination of reactivity constants of the binary system and concludes that it is impracticable.

Considerations in the Use of Glass Reinforced Plastics in Industry and in Chemical Engineering—pp 45-49

Chemical activity is the most important factor in this area, and imposes strict limits on the use of structural and protective materials. Glass reinforced plastics are employed a) where anticorrosive properties or b) where mechanical properties are stressed. Knowledge of the proper resins for use in both these sectors is fundamental to proper application. Physical and chemical characteristics are described. Other sections stress uses of reinforced materials and the manufacture by various means of piping and containers.

France

INDUSTRIE DES PLASTIQUES MODERNES

AUGUST 1960

Extrusion of Vinyl Compounds—(Author—A. Mathé)

The particular qualities, required of an extruded vinyl product, are determined by the end use of the product. The qualities in turn depend on the proper combination of suitable plasticizers, stabilizers, pigments and fillers and on the method of operation. The need for proper combinations and tests of the finished product are discussed.

SEPTEMBER 1960

Raw Material Improvements in the Field of Insulated Wires and Cables—(Author—J. Bele)

The market for insulated wires and cables is not growing on account of the economical expansion only. The complexities of modern installations require not only larger quantities of these products but also qualities, not obtainable commercially at this time. Desired improvements, particularly the need of better process control and tests are described. The need for cooperation between user, raw material supplier and processor is stressed.

L'OFFICIEL DES MATIÈRES PLASTIQUES

SEPTEMBER 1960

Phenol Formaldehyde Resins—pp 615-620

This 8th and final installment of a series on the manufacturing of phenol formaldehyde resins in an underdeveloped country shows the economics of such a factory. Prices are given in $$.

Non-Supported Films—pp 620-626

The old process of producing a casein film by agglomeration has been adapted to a new material, the poly (tetrafluoroethylene). Another old process, the slicing of thick blocks into thin layers is being used now for poly(vinylchloride). An illustrated description of calendering follows. 45 international patent references.

Polyester Resins—pp 647-653

A lively discussion between a manufacturer and his customers. The influence of dilution by styrene and of plastification are discussed. Carborundum powder improves the mechanical properties of a non-reinforced polyester. Tests for deformation at elevated temperatures—ASTM and Martens—are used with a clear resin, but the role of reinforcement or pigments has to be studied in each case.

Unusual Aspects of Compression Molding—pp 627-633

Wood that has been impregnated with dimethylol urea or with a watersoluble phenolic resin lends itself to compression molding. Plasticized nitro cellulose is still the preferred material for billiard balls and casein buttons have a market in France. American and French fabrication of records using vinyl copolymers are described. A similar process is used for printing plates. An American process using poly(vinylidene) chloride and its copolymers as an undercooled melt is quoted and parallels between the shaping of poly(methylmetacrylate) and of glass are developed.

Polymers Containing Silicon—pp 665-670

A list of 307 French patents from 1945 to 1957. To be continued.

Germany

DER PLASTVERARBEITER

AUGUST 1960

Abatement of Noise and Insulation with "ISOSCHAUM"—pp 361-363

The paper discusses the installation and the properties of large surfaces and mechanical components insulated with "Isoschaum" (made by the Schaum Chemie, W. Bauer A. G.). Data on dampening properties are presented as well as the method of installation and application.

Mechanical Acoustical Properties of Expanded Polystyrene—pp 353-360

The excellent paper discusses the mechanical and acoustical properties of expanded polystyrene, in particular those of the BASF "Styropor". Properties discussed are: Bending moment, shear, compressibility, dynamic modulus of elasticity, vibrational properties, and pressure response. Acoustical properties discussed are: resonance, and responses at various sound levels. Sixteen figures and numerous equations are given.

KUNSTSTOFFE

AUGUST 1960

Plastics Packaging Materials and Machines at the 1960 Interpack—pp 447-458

The report attempts to give a systematic picture of the many plastics packaging materials and machines used in their processing seen at the last Interpack Exhibition. Among subjects discussed and reported are packaging materials, plastics packs, adhesives labels, packaging aids as well as packaging machines and similar equipment.

Block and Graft Polymerization of Polymethyl Methacrylate Under the Influence of 60 Co-Gamma Rays—pp 427-431

Using irradiation techniques, block and graft copolymers have been prepared in which the main chain consists of polymethyl methacrylate and the side chains of polyacrylonitrile or polymethylacrylate. The behaviour of the copolymers in the presence of solvents is described. Infra-red spectroscopy was used in analysing the materials.

Boron-Siloxane Elastomers—pp 433-436

Organopolysiloxanes containing hetero atoms are gaining in importance. Boron containing dimethyl polysiloxanes, which contain Si-O-B bonds, are known as "bouncing putty". They contain more than 0.5 Mol. 0/0 boron, are susceptible against hydrolysis and cannot be cross-linked to form elastomers. Hetero-condensates based on organopolysiloxanes and boric acid and organoboric acids with molecular weights of 100,000 to 600,000 can be cross-linked to form elastomers if they contain less than 0.5 Mol. 0/0 boron. These elastomers fuse together even in the fully cross-linked state at room temperature. They are not susceptible against hydrolysis, have excellent electrical properties even after immersion in water, and are used, among other things, as electrical insulation tapes.

The Synthesis and Properties of Cross-Linked, Highly Elastic, Rigid Plastics—pp 437-441

By reacting high molecular, linear, hydroxyl compounds with excess diisocyanates and chain extenders such as for example glycols, cross-linked products possessing excellent rigidity and hardness and high rebound elasticity are obtained, using the reaction mechanism discovered by O. Bayer and his co-workers. These consist of polyurethane chains grafted on to high molecular hydroxyl compounds. The properties are determined by the reaction effect of the two segments in the cross-linked macromolecule.

Methods for the Practical Determination of Stress Crack Resistance of Different Polyethylene Grades—pp 485-490

Since there is some uncertainty about the causes of stress cracking amongst plastic molders, the stresses necessary to produce spontaneous stress cracking in various types of polyethylene are described in a simple manner. A simple test method is described whereby the molder can arrive at an objective opinion regarding the stress crack susceptibility of a given material.

Electronic Instrument for Investigating Shock Resistance of Plastics Film—pp 491-499

An electronically operated tear instrument has been developed which can be used for subjecting plastic film to uni-axial or multi-axial tearing at a progressive speed of 7 m/sec. A complete force-deformation curve is obtained during the test, which can be used to assess film properties which have an effect on short-term behaviour. The results given in another report enable the recognition of registered tear curve for the differentiated assessment of the "impact strength" of the film to be effected.

Intramolecular Cyclisation Reactions in Polymethyl Vinyl Ketones—pp 500-502

The polymerization of methyl vinyl ketone by azo-iso butyric nitrile and the structure of the polymer are discussed. Reactions of the polymeric ketone are described in which only one carbonyl group reacts per basic unit (reduction to secondary alcohol, oxime formation, Girard derivative). Polymethyl vinyl ketone behaves like a 1,5-diketone in a number of other reactions and undergoes intramolecular cyclisation reactions. Conditions have been found under which intramolecular cyclisation becomes the main reaction without crosslinkage occurring.

Characterization of Macromolecular Materials—pp 502-512

It is very important to characterize and classify high molecular substances precisely in order to identify two or more macromolecular materials as being the same or different. This point is made in the paper. The author also shows how the classification affects the production of "tailor-made" macromolecules. Also discussed are the relation between characterization, copyright protection and documentation of such macromolecular materials. This characterization can be effected by using the sum of the basic parameters giving direct information on the individual macromolecules. As criterion for establishing dissimilarity of two macromolecular substances, a deviation for example, of at least 20%, outside the margin of error of at least one basic parameter is suggested. The various methods used to obtain these parameters are briefly described.

Design to Finished Article—A Discussion on Design, Construction and Manufacture—pp 529-534

During the recently held Plastics Exhibition at Dusseldorf the brave attempt was made to have a special theme treated in the form of discussion. Five experts were involved in this discussion, and there was a certain measure of agreement in the matter of selection of suitable molding material and constructive solution. Naturally, the discussion was prepared beforehand, even if only for the sake of the pictures which illustrated it, but the actual conversation itself was based on brief notes. The discussion is presented here in a slightly abbreviated version.

*Johnson reel (Denison-Johnson Corp.); Imperial 8 radio (Admiral Corp.); Aqua Hone sharpener (Sun Enterprises, Inc.)

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SECTION NEWS

Golden Gate Section

Golden Gate RETEC

Technical program of the RETEC, attended by 155 registrants, comprised ten papers and a movie covering virtually every method of combatting corrosion using plastics and plastics materials. At the luncheon Mr. Bolton discussed "Chemistry in Computers" with particular emphasis on the increasing use of plastics in these complex memory systems. President Martin's address on the "Progress and Future of SPE" outlined Society activity in 1960 and included a gaze into the crystal ball of the future.

The RETEC was kicked off with a welcoming address by San Francisco Mayor George W. Christopher, who is well acquainted with plastics as utilized in the food packaging industry.

Upper Midwest Section

New Materials Night

CHARLES M. SMITH
(Donaldson Co.)

The first meeting of the 1960-61 season, was held September 19, in Minneapolis. The subject was "New Materials Night" presented by B. F. Goodrich Company and E. I. Du Pont de Nemours and Company.

Mr. Jean F. Malone, Manager—Sales Development Plastic Materials Sales of B. F. Goodrich lectured on recent developments in the rigid polyvinylchloride field, and three of the new products which B. F. Goodrich Chemical Company is in the process of marketing. In the latter category are hi-temp Geon, vinyl with exciting new properties; Estane, a new polyurethane with outstanding properties and process characteristics; and Abson, a new and improved ABS resin.

B. F. Goodrich Chemical Company believes that the continued growth of rigid PVC will come from both the established rigid vinyl compounds as well as from the new developments in this field.

The second lecture was presented by Charles H. Concklin of the E. I. Du Pont de Nemours and Company. Mr. Concklin's lecture was on Teflon, FEP-Fluorocarbon Resins. Teflon 100X FFP-fluorocarbon resin is a fluorinated ethylene-propylene polymer produced by combining tetrafluorethylene and hexafluoropropylene. In properties, 100X is very similar to the older Teflon-TFE; however the 100X resin, unlike TFE types, can be molded and extruded pretty much like other thermoplastics.

Fabricators of 100X convert the resin into wire insulation, cable jacketing, tubing, sheet, complicated extruded and molded shapes, rods, bottles, molded and vacuum formed parts, and fluidized bed coatings.

Milwaukee Section

Talk on Extrusion

C. H. STRONG
(Union Carbide Plastics Co.)

The Milwaukee Section held its initial meeting on September 20 with a turnout of 55 members and guests.

Speaker for the evening was A. M. Soutar, technical representative on extrusion from E. I. du Pont de Nemours & Company. Subject of his talk was flow studies of polymer melts in extrusion molding. He talked about the polymer in channels in extruders and how granules integrate. He pointed out through the die how stresses and dead spaces were formed. They show on the wire coatings. A question-and-answer program followed.

Head table at the Golden Gate RETEC on "Plastics vs. Corrosion" in San Francisco on October 5 included, seated (from l. to r.) Luncheon Speaker W. D. Bolton, IBM Corporation; Section President Brantley I. Newsom, Wilson & Geo. Meyer & Co.; SPE President George W. Martin, Holyoke Plastics Co.; and standing Thomas A. Bissell, SPE Executive Secretary; RETEC General Chairman J. W. Richardson, Rohm & Haas; and Robert D. Forger, SPE Administrative Assistant.

Speakers and Moderators of the Golden Gate Section RETEC on "Plastics vs. Corrosion" in San Francisco on October 5. Front row (from l. to r.) Program Chairman John Joyce, Western Plastics Magazine; S. M. Robertson, Koppers Co., Inc.; Lawrence Graubart, Reichhold Chemicals, Inc.; George M. Taylor, Hercules Powder Company; Dr. Raymond B. Seymour, Sull Ross State College; and Jack G. Fuller, Jr., Chemtrol Co. Standing (from l. to r.) Moderator L. G. Maclise. Dow Chemical Co.; David A. Bisson, Union Carbide Plastics Co.; O. E. Larson, Phillips Chemical Co.; S. E. Susman, Narmco Industries, Inc.; W. P. Gideon, Eastman Chemical Products Co., Inc.; Moderator Frank D. Allen, L. H. Butcher Co.; and E. B. Osborne, B. F. Goodrich Chemical Co.

St. Louis

Foamed Polystyrene

RICHARD H. KOEHRMAN
(International Shoe Co.)

The October meeting of the St. Louis Section was held at the Clayton Elks Club on October 17, 1960. Thirty-five members and guests were present with the new president, Mr. B. M. Coons presiding.

Following dinner, the speaker was Mr. J. Dunmire, of the Kopper Co., Technical Service group, whose subject was foamed polystyrene. The talk covered the blowing operation, the molding and properties of the material. Slides were shown of the many products now being produced with this material.

On October 13, the officers, directors and committee members met at a dinner meeting with Mr. R. D. Forger of the National Office of SPE to discuss the relations between the Section and the National Office.

Akron

Double-Header

GEORGE REESMAN
(Rubbermaid, Inc.)

For the second month the Akron Section presented dual speakers. Having two speakers talking on unrelated subjects has increased attendance remarkably and will be continued.

Mr. William Blamey of the Auto-Vac Co. spoke on "Thin Wall Containers—Vacuum and Blister-Forming Equipment". His talk consisted in part of a film showing the operation of Auto-Vac's latest vacuum-forming equipment, and was very interesting.

Mr. Ralph Hammer of the Monsanto Chemical Co. gave an excellent talk on "Latest Developments of Foreign Injection Molding Machinery". Mr. Hammer spoke with authority as he has just recently returned from an extensive tour of Europe where he spent considerable time in various molding plants. Mr. Hammer made the observation that the Europeans are far ahead of us in machine developments and molding techniques.

Pioneer Valley

Pioneer Valley

ROGER JOHNSTON
(Foster Grant)

Another good crowd, gathered for the October meeting.

Mr. Richardson and Mr. Shields led their audience through a fantasy of form and color ranging from a lunch box to a pumpkin in discussing methods of design.

The workshop on injection molding in Spring 1961 is progressing and the committee have promised some really good lectures in the next months.

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Buffalo

Molding of Linear Polyethylene

J. P. VALENTINE
(Hooker Chemical Corp.)

The regular monthly dinner meeting of the Buffalo Section was held October 10, 1960 at the Continental Inn Hotel, Buffalo, New York. Forty-two members and guests heard Lyle Smith of Phillips Chemical Company introduce Bob Craig, who discussed the molding of linear polyethylene.

The discussion included the effect of such things as mold temperature, stock temperature and weight of charge or impact strength. Gate location depends on part design and rate of injection.

Hot runner molds were discussed. Two variations include insulated runners, and torpedo type heaters.

During the business part of the meeting, Bill Dunmyer, Carborundum, Section President, appointed George Chadwick, Speer Carbon, as ACS Liason to discuss a joint meeting. Bill Windover, Durez Plastics, reported on progress in setting up a Student Chapter at Erie County Tech.

Newark Section

Enjay Labs Tour

R. E. CHRISTENSEN
(Union Carbide Plastics Co.)

About three hundred fifty members and guests of the Newark Section were treated to an interesting and informative evening on October 18th by the Enjay Laboratories in Linden, N. J. Three introductory talks preceded a tour. Mr. E. F. H. Pennekamp, Director of Enjay Labs, explained the Enjay Labs function as the technical arm of the Enjay Chemical Co. Mr. J. K. Nelson, Vice President of Enjay Chemical Co., pointed out that Enjay has long been a supplier of raw materials for the plastics industry and that entry into the field as a supplier of polypropylene was a natural extension of previous efforts. Mr. Charles E. Farnsworth, Manager of the Plas-

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Mayor proclaims Plastics Week in Newark, pointing up the Newark Section's sponsorship of a Scholarship Award at Newark College of Engineering. Shown left to right: John Ward of Bayonne, N. J., recipient of the Scholarship Award; Mayor Leo P. Carlin; Ernest J. Csaszar, Past President and Albert Spaak, President of Newark Section; and Kenneth Diehl, Coordinator of Evening Courses at N.C.E. Other recipients of the Scholarship Award made this year are: Wilkes H. Davis, Raymond H. Leto and John E. Novak.

During tour of Enjay Labs plastics laboratories, SPE members visited physical testing laboratory where James A. Rabideau, far right, described equipment used to evaluate and study physical behavior of various polypropylene formulations.

tics Division, described some of the interesting problems associated with getting into the production of polypropylene. President Al Spaak announced plans for the Christmas Party this year for members and their wives on December 14th. Director Vic Blatter is chairman of this event.

Northwest Pennsylvania

Phenolic Molding

LLOYD ENGLISH

(Louis Marx Co. of Pennsylvania)

A dinner meeting was held at the Corry Hotel in Corry, Pennsylvania on October 27th. The speaker, introduced by section president Fred Kraft, was Mr. Edward W. Vaill, technical service engineer from the New York headquarters of Union Carbide Plastics Company.

Mr. Vaill gave an interesting and informative talk on "Practical Phenolic Molding Techniques" illustrated by projected color slides.

Philadelphia Section

Two Symposia Presented

GEORGE R. DeHOFF

(E. I. du Pont De Nemours

The Philadelphia Section borrowed a page from the ANTEC format for its meeting on October 25, 1960. Over 140 members and their guests—the largest attendance for a regular meeting in the section's history—were present for a Divided Meeting. One session was on Characteristics of Plasticized PVC Resins and the other, conducted simultaneously in another room, was on Maintenance and Plant Layout.

Chairman, J. P. Clancy of Emery Industries had Mr. D. T. Zentmyer of Armstrong Cork Company as moderator for the Vinyl Resins Group and the following speakers: Mr. Russell A. Park of Firestone Plastics Co. speaking on "Effects of Plastisol Resins upon Processing Characteristics and Physical Properties of Plasticized PVC," Mr. R. W. Annonio of Union Carbide Plastics Co. discussing "Solution Resins" and Mr. Neil T. Flathers of Escambia Chemical Corp. on "Dry Blend PVC Resins."

Chairman John J. McGraw, National Vulcanized Fiber Corp. had two representatives of the equipment manufacturing industry to discuss Maintenance and Layout. Mr. McCormick of Davis Standard Corp. spoke on "Extruder Maintenance" and Mr. H. J. Henry of Reed Prentice discussed "Plant Layout."

Sam Greenwood, National Council representative was introduced. Mr. Greenwood announced the new officers of the Society and reviewed the current activities of the National Council. In his review he cited the number of Retecs scheduled for 1961, our growing membership, and pertinent budget items.

Rochester Section

Blow Molding

DAVID L. MESSENGER

(Stromberg-Carlson Div., General Dynamics)

The October meeting of the Rochester Section was held at Logan's on October 10, 1960.

The program for the evening featured a panel discussion covering machines, tooling, materials and techniques in modern blow molding. The panel consisted of Mr. Peter T. Schurman of Protective Closures, Inc. who spoke on materials, Mr. Fred W. John of the Nalge Company who covered tooling, Mr. Howard J. Hill, Jr., Fisher Price Toys, Inc. and Mr. William J. De Witt, Jr., Shoe Form Company, Inc. who spoke on Machines and Techniques. Each panel member very ably handled his part of the discussion as well as specific questions directed to them following their talk. Many sample blow molded parts were available for inspection and these provoked considerable question activity.

Southern California

New Equipment Topic

Irwin M. Zelman

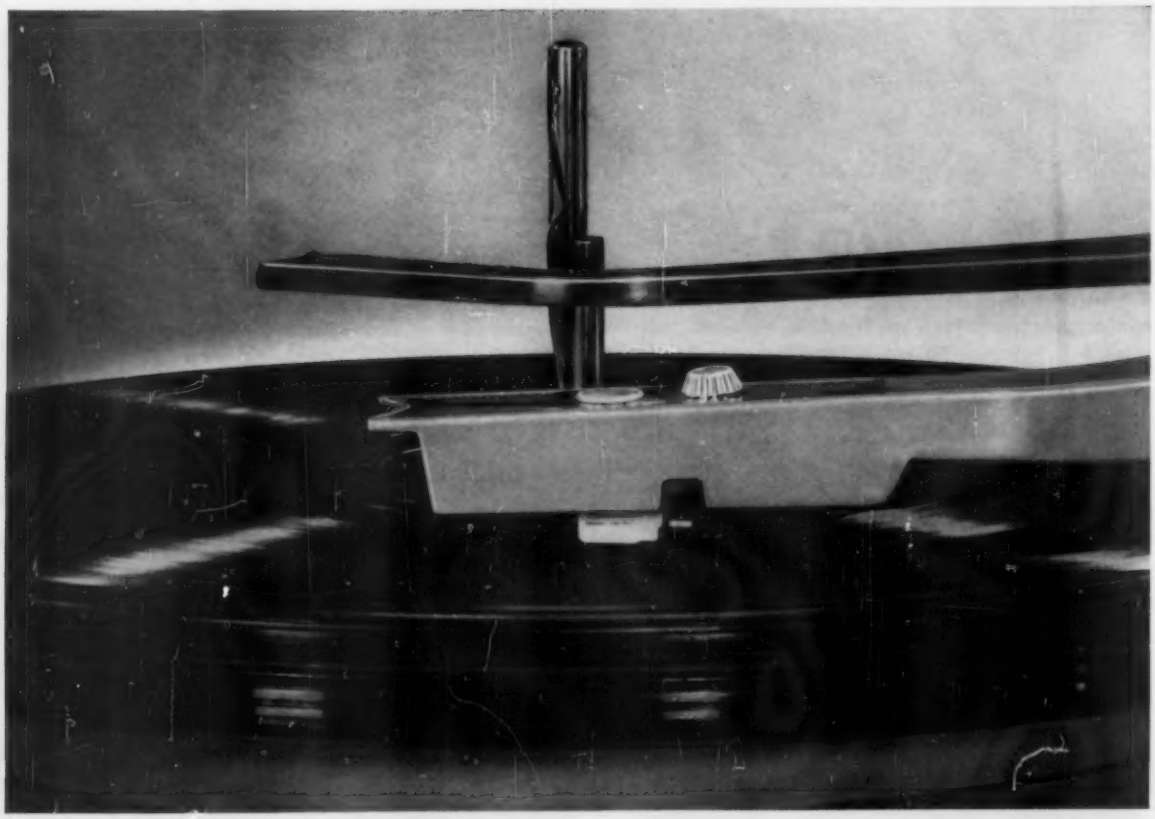
(American Reinforced Plastics Co.)

The September meeting, was attended by approximately 150 members and guests gathered to hear a panel discussion on "New Developments in Equipment".

Martin Usab, Dynatech Plastics, Inc., opened with an explanation of new injection molding equipment. He explained that in Europe, 80% of the machines are based on the newer screw-plasticizing system rather than the standard plunger method presently used in most U. S. machines. Laminar flow and distortion, often resulting from the heating differential inherent in the older plunger method, are thus almost entirely eliminated.

Elmo Aylor, Rocketdyne, discussed the principles and equipment used in the present filament winding operations that lend themselves to uses in rocket engines and space vehicles.

Charlie Zimmerman, West Coast Plastics Distributors Inc., explained the methods of operation, new features and improvements offered by firms manufacturing extruders and blow molders.



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ABOUT MEMBERS

Paul Roche and **Bill Hayes,** formerly of Nosco Plastics, Erie, Pa., have formed a partnership and started Erie County Plastics, an injection molding operation, in Corry, Pa.

J. H. Burris has been named manager of the newly organized Thermal Power Department of Allis-Chalmers Power Equipment Division. The new department is a combination of the old steam turbine and heat transfer departments. Mr. Burris was assistant general manager of the Power equipment Division since 1956 and joined Allis Chalmers in 1937.

Mr. Morehouse

Larry C. Morehouse heads up a newly - established Packaging Equipment Department at F. J. Stokes Corp.

Herbert S. Lecky and **Bailey H. Barnes,** both members of the Philadelphia Section, have assumed new posts in the Du Pont Co. Mr. Lecky was appointed manager of marketing and Mr. Barnes takes over as field sales manager of Du Pont's new Polyolefin Division.

The Newark Die Co. has announced the promotion of **Victor P. Bergquist** as Plant Manager. Mr. Bergquist joined the company in 1934 and has held a number of production posts.

Mr. Doolittle

H. A. Doolittle, General Manager of its Stimsonite Division (Chicago), has been elected Vice President of the Elastic Stop Nut Corporation. Mr. Doolittle has directed the development of production of optically correct molded plastics for military, automotive, highway and commercial uses. He is a graduate of Illinois Institute of Technology.

Indio Braile, former Export Sales Manager (Plastics) for Ballagh and Thrall of Philadelphia, has joined the International Marketing Division of AviSun Corporation, Marcus Hook, Pa. Dr. Braile, a native of Brazil and a graduate of the University of Bologna, Italy, has spent 18 years in the plastics industry in Brazil and the U.S.

Ernest J. Csaszar has been named Director of Sales for the Newark Die Co. and its subsidiary, Newark Die Hobbing and Casting Co. Mr. Csaszar is past president of the Newark Section of SPE and has been active in SPI. During World War II he served as a consultant with the Naval Ordnance Laboratory in Washington, D. C. Mr. Csaszar is also Feature Editor for Moldmaking of SPE Journal.

Mr. Suiter

William A. Suiter, formerly Cycolac resin Sales Manager, has been named a vice president of the Marbon Chemical Division of Borg-Warner Corp. He will be responsible for product sales activities, including rubber, resins, latex and adhesives sales.

Mr. Donalds

John E. Donalds takes over as manager of coating sales, Dow Chemical Co. Donalds has been Dow's plastics district sales manager in Detroit since 1957.

Harry T. Douglas has resigned as Vice President of Lunn Laminates, Inc. Mr. Douglas has been with the company since 1947.

George Flanagan takes up duties as Manager of Defense Sales and Services, B. F. Goodrich Corp., Cleveland, Ohio. Mr. Flanagan headed the company's Washington D. C. office for 8 years prior to returning to the Cleveland area. He will still be responsible for his company's interests in the Washington area and will spend about one week of every month in that city.

Mr. Metzler

Robert J. Metzler, formerly Vice President and General Manager of Ludlow Plastics, Division of Ludlow Corp., has been promoted to Vice President of Manufacturing for Ludlow Papers and Ludlow Plastics divisions. **John J. Kelville** will continue as Director of Marketing of Ludlow Plastics.

Charles. A. Breskin of New York was awarded the Plastics Institute of Australia's John W. Derham Memorial Lecture medal. During his Australian tour, Mr. Breskin addressed several PIA meetings, as well as the Third Australian Plastics Convention and Exhibition and the National Packaging Association of Australia.

Holy Cross College has appointed **Richard B. Bishop,** consultant in plastics and petrochemicals, to the post of Research Associate with the responsibility of supervising graduate students and senior undergraduates working in polymers and related fields. Mr. Bishop took his B.S. and M.S. degrees at Holy Cross and has been connected with Socony Mobil Oil Company and Foster Grant Company, where he was Director of Research.

Mr. Stryker

Reichold Chemicals, Inc. has named **Charles S. Stryker** as Coordinator of its Reinforced Plastics Division and Sales Manager of its specialty Chemicals Division. Prior to his appointment, Mr. Stryker was Manager of Technical Services in the Polyester and Epoxy Resin Department.

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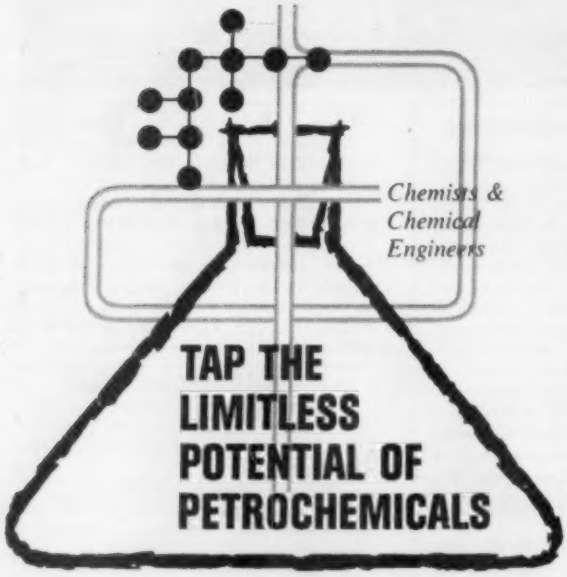

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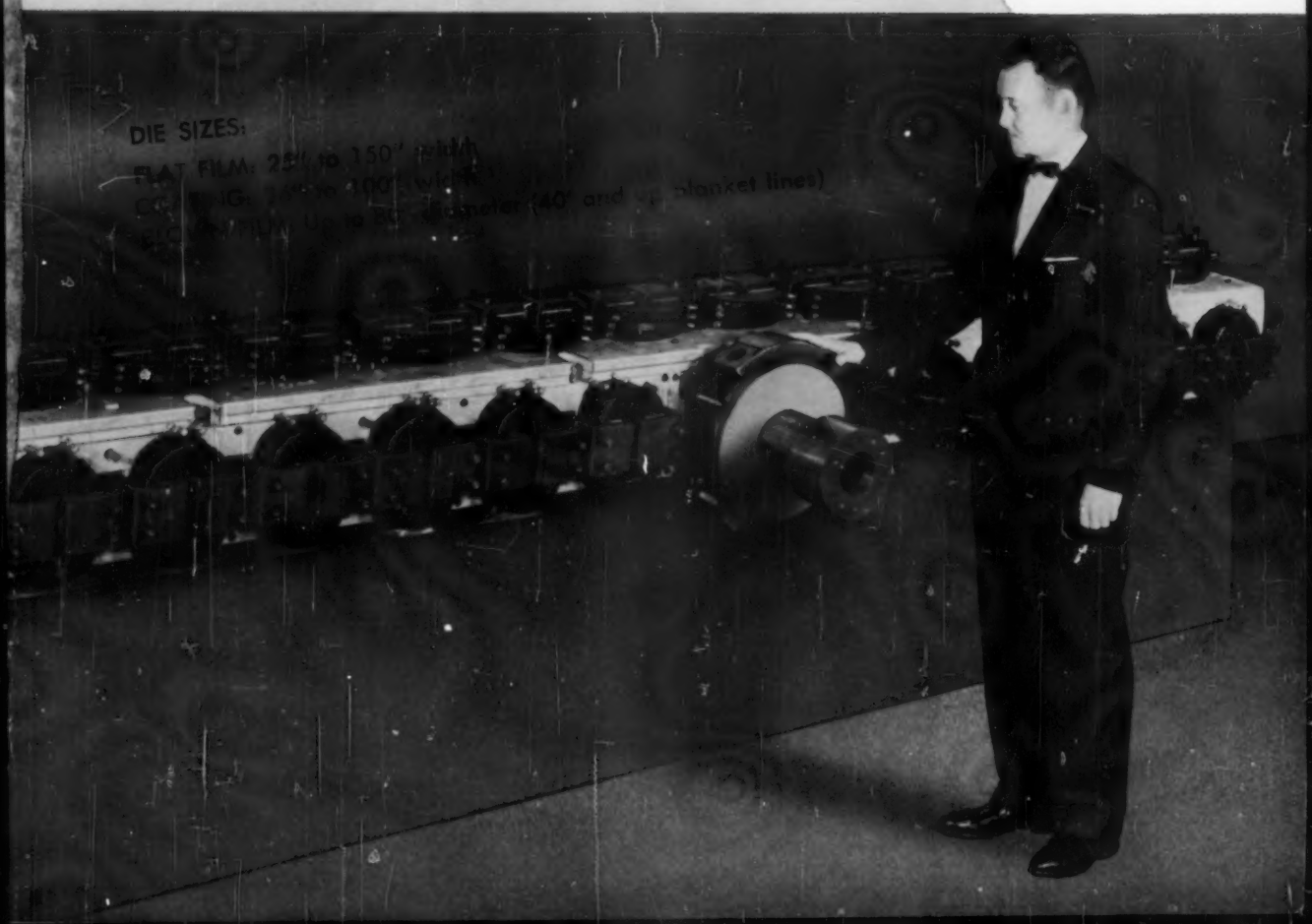

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